

Master thesis in Economics and Business Administration

Faculty of Economics and Social Sciences

Revised MARPOL Annex VI effects on Northern European short Sea Shipping

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This thesis was written as a part of the Master of Science in Economics and Business Administration program - Major in international Economics and Shipping. Neither the institution, nor the advisor is responsible for the theories and methods used, or the results and conclusions drawn, through the approval of this thesis.

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Table of Contents

List of figures.....	iii
List of tables.....	iv
1 Introduction	1
1.1 Introduction & Background	1
1.2 Aims & Objective	2
1.3 World trade and technological trends	3
1.4 Liner operations	4
1.5 Short sea shipping	5
1.6 Maritime regulatory system.....	6
1.6.1 IMO	7
1.6.2 MARPOL.....	8
1.6.3 MARPOL Annex VI	9
1.6.4 MARPOL Annex VI revised.....	9
2 Theoretical framework	11
2.1 Trade theory	11
2.1.1 Comparative advantage	11
2.1.2 Autarky adoption.....	14
2.1.3 Gains from trade.....	15
2.1.4 Heckscher and Ohlin	17
2.3 Partial equilibrium in competitive markets.....	20
2.3.1 Demand	21
2.3.2 Supply	24
2.3.3 Market equilibrium.....	27
2.4 Scale economies	28
2.4.1 Short & long run supply curve	29
2.5 Market structure in liner shipping.....	31
2.5.1 Liner conferences & alliances.....	31
2.5.2 Few transport providers	32
2.6 Discrimination and differentiation	34
2.6.1 First degree price discrimination.....	35

2.6.2 Second degree price discrimination	36
2.6.3 Third degree price discrimination	37
2.7 Externalities in shipping	38
2.7.1 Externalities in a free market	39
2.7.2 Environmental regulations	40
3 Transport economics	43
3.1 Transport markets	43
3.2 Supply & demand determinants in shipping	44
3.3 Transport supply.....	45
3.3.1 Shipping costs.....	45
3.4 Transport demand.....	53
3.5 Pricing transport services	61
3.5.1 Liner service pricing.....	61
3.5.2 Aggregated transport supply.....	65
3.5.3 Aggregated transport demand.....	67
3.5.4 Clearing of aggregated transport supply and demand.....	68
4 Market effects & reactions.....	70
4.1 Sulphur reduction alternatives and costs.....	70
4.1.1 Sulphur abatement technology.....	71
4.1.2 Cost & availability of distillate fuels	74
4.2 Assumptions & Freight rate increase	77
4.3 Effects on liner shipping	83
4.3.1 Effects on transport demand.....	83
4.3.2 Modal shift	87
4.4 Conclusion	90
5 Discussion	92
5.1 Objectives were met	92
5.1.1 Difficulties met with research & data collection.....	92
Bibliography.....	94

List of figures

Figure 1: World trade	3
Figure 2: Overview of the regulatory system.....	7
Figure 3: (Sulphur) Emission Control Area	10
Figure 4: Consumption Possibilities	13
Figure 5: Production Possibility Frontier	14
Figure 6: Adoption In an autarky.....	15
Figure 7: Autarky and free trade adoption	16
Figure 8: Hecksher and Ohlin theory.....	18
Figure 9: Demand curve	22
Figure 10: Income effect	23
Figure 11: Cost curves	26
Figure 12: Market adoption with free trade	27
Figure 13: Short & long-term average cost curves.....	29
Figure 14: Short & long run supply curve.....	30
Figure 15: Shipping conferences & freight rates.....	33
Figure 16: First degree price discrimination	35
Figure 17: Second degree price discrimination.....	36
Figure 18: Cost of externalities	41
Figure 19: voyage distance VS ship size	48
Figure 20: CIF and FOB relationship	51
Figure 21: Income & substitutin effects	57
Figure 22: Liner service costs	62
Figure 23: Marginal cost pricing	63
Figure 24: Fixed pricing	64
Figure 25: Aggregated transport supply	66
Figure 26: Aggregated demand.....	67
Figure 27: Clearing of aggregated transport supply and demand	68
Figure 28: Seawater scrubbing	72
Figure 29: Price\$/mt MGO VS. LS 380.....	74

List of tables

Table 1: Sulphur limits.....	10
Table 2: Low value VS high value Goods	55
Tabell 3: Different transport quality	55
Table 4: Calculations of freight rate effects with IFO 380 Price at 300\$ (\$000 per voyege) ...	80
Table 5: 3 Year Rotterdam IFO 380 prices.....	81
Table 6: Calculations of freight rate effects with IFO 380 price at 700\$ (\$000 per voyage) ...	82
Table 7: Change in transport costs.....	85

Abstract

After an increasing focus towards the adverse effects caused by air emissions from the shipping industry IMO decided to implement stricter environmental regulations towards the shipping industry. These regulations were adopted in the revised MARPOL Annex VI, which concerns these matters. After the revision there has been some criticism towards the new regulations, especially from some of the north European liner firms claiming that they will face unsustainable cost effects, while other firms commend the new regulations.

This thesis is divided in to five parts where, part one presents an introduction for the reader, in order to give information on the basic relevant background in the shipping industry concerning the thesis, as well as the aims and objective of the thesis. The second part includes the theoretical background needed to understand the basic elements in trade theory and microeconomic theory, in order to further explain transport economics, which is introduced in part three. Part four will be devoted to study and analyze the effects of Annex VI on the north European short sea shipping industry. Part five is dedicated to a short discussion regarding the findings and research methods.

1 Introduction

1.1 Introduction & Background

In the last years the shipping industry has been subject to ill repute concerning the increasing emissions from the industry. According to a UN rapport concerning the environmental impact caused by the shipping industry, air pollutants mainly, Nitrogen oxides (NOx) and Sulphur Oxides (SOx) are expected to rise by at least 30% by 2020, if nothing is done to reduce these emissions by then, total SOx and NOx emissions from the ships in EU are set to be greater than all land based sources combined.

According to a rapport from the European Environmental Bureau (EEB) particulate matters (PM) cause a number of serious health and environmental impacts including lung cancer, acid rain and respiratory problems (eeb.org, 2004). According to an article in the guardian, the shipping industry is accountable for 60,000 deaths yearly due to the extensive use of “dirty” bunker fuel (Vidal, J. 2008).

Because of these severe health and environmental effects the IMO decided to implement stricter regulations (MARPOL Annex VI) concerning air emissions from the shipping industry. Firstly these regulations will primarily concern sulphur emissions. There exists sulphur reducing measures today by which these pollutants can be reduced by as much as 90-100 %; however these procedures will bring additional costs to the shipping industry and consequently the shippers.

According to a number of industry participants the bunker, prices could rise as much as 100% as a result of these new regulations, which consequently can lead to a freight rate increase of 20-50% depending on industry specific and macroeconomic factors. Recently a rapport made on a request from the Finnish government concluded that the revised Annex VI could cost Finnish businesses up to 1,6 billion dollars as a result of increased freight rates. (Eason, C. 2009)

This thesis will discuss the effects faced by shipping companies operating in (S)ECA (Sulphur emission control area) areas as a consequence of the revised MARPOL Annex VI. The specific focus will be on short sea container services and possible supply/demand distortions. The purpose is to provide a theoretical framework aimed at determining how changes brought by Annex VI will affect the industry in focus.

1.2 Aims & Objective

In most cases the shipping industry is in a somewhat unique position as the freight rates are relatively low compared to the value of the cargo, and the fact that in larger hauls the shipping industry has no real competitors because of the vast stretches of sea. But in short sea shipping, especially in the container shipping industry, land based transport can be a fierce competitor particularly on the shorter hauls. The short sea shipping market in Europe consists of a variety of ships which have been and will continue to be affected by environmental regulations in the future. The affects will almost always induce some sort of increased cost to the industry and I will, thus, briefly outline the aims and objectives on which this thesis will focus on.

Aim

- ✓ To analyze the effects of Marpol Annex VI 0.1% sulphur cap on bunker fuel within (S)ECA areas on short sea liner shipping.

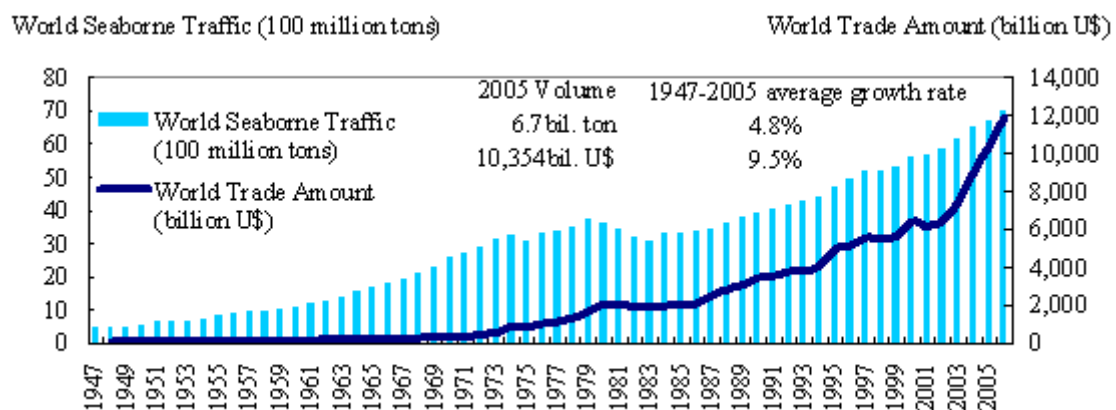
Objectives

- ✓ Analyze the effects on trade patterns.
- ✓ Analyze the effects on demand for short sea transport.
- ✓ Analyze the effects on freight rates.
- ✓ Analyze the effects on distillate bunker supply/price.
- ✓ Analyze the effects concerning modal shifts away from short sea shipping

1.3 World trade and technological trends

Increasing industrialization and more liberalized markets has resulted in a significant overall growth in world trade over the last century. Today over 90% of world trade is transported by sea; this means that seaborne trade is by far the main means of transporting goods (imo.org₁).

Figure 1: World trade



Source: Fearnleys (2006)

As the figure above shows the world trade average growth rate since 1947 was 4,8%. This exceptional development is owed to the technical innovations and specialization in the shipping industry. It became evident in the post 1945 period that tramp shipping was too labor-intensive to be efficient, and the industry had to develop more efficient ways to transport goods. As a result of this, the industry moved towards specialization and larger vessels to exploit the economies of scale (Stopford, 1997).

The development in the bulk shipping industry was mainly motivated by the multinational oil and steel companies, who moved their processing plants to coastal areas closer to costumers, allowing for larger cargo-parcels and more efficient transport systems, and reducing the total cost of raw materials. It soon became obvious that something had to be done with the difficulties facing transportation of general cargo as well (Stopford, 2009).

The solution became containerization which has been a revolution for the means of transporting general cargo, not only for liner companies but for all involved in transporting goods, since the containers were standardized the whole transportation process was considerably more effective than the labor intensive transportation in the past (Stopford, 2009). There were however some cargoes that did not fit in either the container or the bulk shipping system. These commodity groups such as cars, chemicals and forest products, faced high transport costs and were often damaged during transport. The industries solution to that problem was to develop specialized ships for these commodities, resulting in what we today know as chemical tankers and car carriers (Stopford, 2009). All these cost effective measures from different industries along with the liberalized markets has led to the globalized world we see today.

1.4 Liner operations

The liner shipping industry plays a vital role in the global trading network, as the industry carries approximately 60% of the value of goods shipped by sea today (Stopford, 2009). Liners have evolved to be an efficient and reliable transport mode over the last 130 years, first starting out with the invention of the steam engine resulting in increased supply of transport which stimulated demand.

Until the 1960's liner companies used multi-deck vessels also known as cargo liners which had their own cargo handling gear. This meant that the cargo handling was time consuming and inefficient. Standardization of general cargo was the solution to the efficiency problems and the modern container ship as we know it today was born in the sixties (Stopford, 2009). Because the containers were standardized it was much easier to implement an efficient door to door service than before.

A prominent feature of liner shipping is the obligation to provide a fixed service, at regular intervals, between specific ports. This feature often creates problems linked to unbalanced cargo flow, like increased cargo planning and load imbalances by direction. This means that one of the biggest challenges in both cost control and logistics management facing liner shipping companies today is the problem of providing the right shipping supply to match the

direction of the heaviest demand. This difficulty will in some cases lead the liner company to take on low value “bottom cargo” on the legs with the lowest demand, in order to cover a part of the voyage costs, which to some degree makes liner services and minor bulk transport competitors on some hauls (Stopford, 2009). Another problem regarding the liner industry is the obligation to stick with their schedules even if demand weakens, whereas in the spot market one can respond to supply-demand imbalances by laying up the least efficient ships until equilibrium is reached again (Stopford, 2009).

1.5 Short sea shipping

Short sea shipping has great impact on distributing cargo within regions. The economical benefits of short sea shipping can be favorable because of the economies of scale and the fact that it reduces accidents on the competing land transport routes. The environmental benefits in the case of reduced Co2 and road congestion are also significant (Musso, E and Marchese, U.2002).

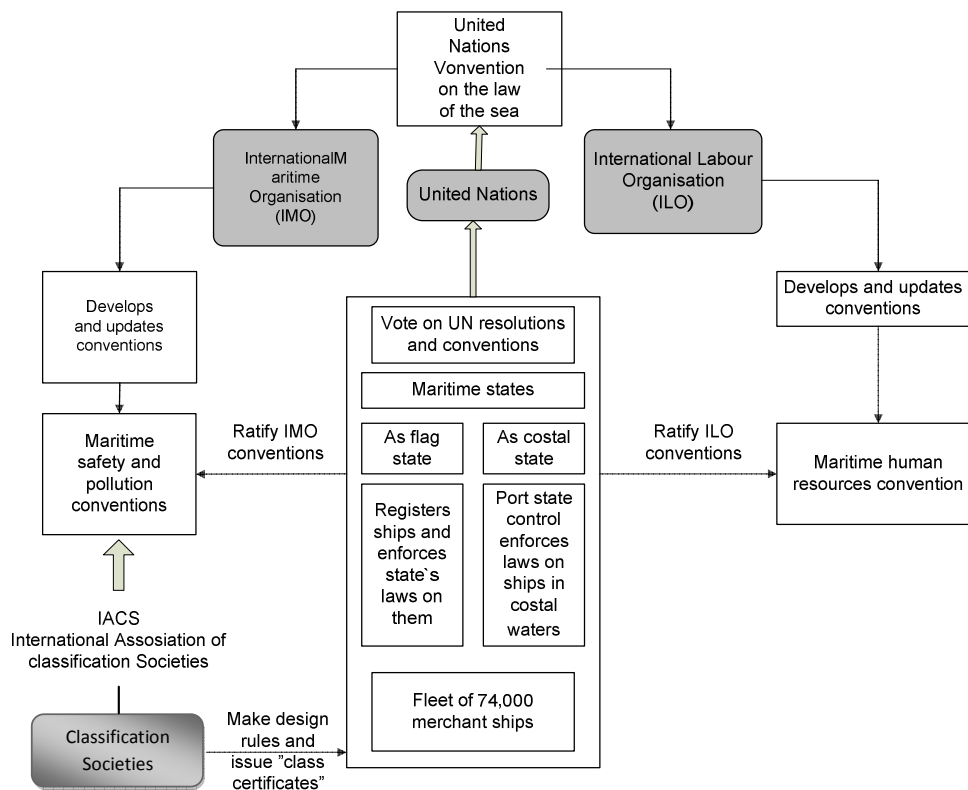
Short sea ships do not differ significantly from the ships used in deep sea trade except that they are generally smaller which means that they are more versatile and have the ability to enter shallower waters and therefore a greater number of ports. This makes short sea shipping ideal for providing port-to-port service from bigger ports like Rotterdam to smaller ports and are in direct competition with land transport. This is especially relevant on the European arena, as the geographical and economical conditions are more favorable towards land based transport than in for instance Asia where the infrastructure is less developed (Musso, E and Marchese, U.2002). This means that the demand for short sea shipping in Europe is more elastic, resulting in increased competition among transporters and more attention to cost efficient transport systems and cost savings.

1.6 Maritime regulatory system

There has always been a conflict of interest between ship-owners and the regulatory authorities in shipping. The reason for this is that the ship-owners feel that regulations increase costs which again reduce profits. The goal of maritime regulations is to ensure that every player acts according to the same statutory framework that companies on land have to apply to. Some incidents have influenced directly to the making of new regulations; one of the most recent ones is the Exxon Valdez that ran aground in Alaska March 1989 and spilled 37,000 tons of crude oil. This caused the US congress to pass a law which stated that all single hulled tanker should be phased out from operating in US waters within a final date in January 2015 (OPA, 2000). This later led to regulation 13G in Marpol 73/78, making a single hulled tanker phase-out mandatory (imo.org). This phase-out was later accelerated due to the sinking of the Erika in 1999 and the Prestige in 2002 (intertanko.com, 2005).

Since shipping is a global business and the ships spend considerable time in international waters, it is hard to set specific boundaries related to who regulates the shipping industry and what to regulate. Today it is the United Nations that has the principal assignment of coordinating the interests of different participants in the shipping industry. The broad framework is set by the law of the sea; in addition to this the two UN agencies IMO (International Maritime Organization) and ILO (International Labor organization) have the tasks of maintaining regulations within the framework set by the UN (Stopford, 2009). IMO is mainly responsible for regulations concerning ship safety, pollution and security, while the ILO is responsible for laws regarding the people that work on the ships. Because of the regulative scope of this thesis focus on regulations concerning pollution, further emphasis will be on IMO and its underlying conventions. The figure below shows how the maritime regulatory system are built up and coordinated.

Figure 2: Overview of the regulatory system



Source: Stopford, M (2009) *Maritime Economics 3rd Ed.*
 London: Routledge p.657

1.6.1 IMO

Until the middle of the 20th century the lack of regulations and international laws caused problems for the shipping industry (Stopford, 2009). The reason for this was the lack of international cooperation between countries especially the ones that traded by sea. When the United Nations was established, they formally adopted a convention in Geneva in 1948 that became the IMO (IMCO then). This convention went into force in 1958 and the members of the new organization met the following year (imo.org, 2009₁). Today IMO has 168 member states and three associate members; the headquarters is based in London with a workforce of about 300 people. (imo.org, 2009₁)

The governing body of IMO consists of five committees that carry out technical and legal work (Stopford, 2009):

- Maritime safety committee
- Marine environment protection committee
- Technical co-operation committee
- Legal Committee
- Facilitation Committee

The first treaty adopted by IMO was named the Safety of Life at Sea (SOLAS) and was aimed at the improvement of the safety of shipping. This treaty was adopted in 1960 and came into force in 1965. After that, it was updated in 1974 to incorporate an amendment procedure that takes account of changes in the shipping environment without major procedures. The importance of the SOLAS Convention is emphasized by the fact that it had been ratified by states representing 99 % of the world merchant fleet in October 2006 (Stopford, 2009).

1.6.2 MARPOL

The International Convention for the Prevention of Pollution from Ships (MARPOL) is a renewal of the convention for prevention of Pollution of the sea by oil (OILPOL) that was adopted in 1954. The reason for OILPOL's establishment was the increasing volumes of oil shipped by sea and the problem of uncontrolled discharge of oily ballast water off the loading ports causing polluted beaches and seas (Stopford, 2009).

In the 1960's especially after the Torrey Canion ran aground when entering the English Channel spilling 120,000 tons of crude oil, the need for additional regulations regarding marine pollution was apparent, and in 1973 MARPOL was adopted. (imo.org₂) The main tasks of MARPOL is to prevent and reduce pollutions from ships, this can be either accidental incidents as well as pollution related to routine operations.(imo.org₂) MARPOL has at this point six technical annexes which covers the details of the regulations(Imo.org₂):

- Annex I: Regulations for the prevention of pollution by oil
- Annex II: Regulations for the control of pollution by Noxious Liquid substances in bulk
- Annex III: Prevention of pollution by harmful substances carried by sea in packaged form
- Annex IV: Prevention of pollution by sewage from ships
- Annex V: Prevention of pollution by garbage from ships
- Annex VI: Prevention of air pollution from ships

1.6.3 MARPOL Annex VI

After several amendments to Annex I in the 1990's related to the phasing out process of single hulled tankers, IMO's attention shifted to the environmental impacts caused by the shipping industry's emissions (Stopford, 2009). This resulted in the adoption of Annex VI which sets the rules regarding sulphur dioxide (SO_x) and nitrogen dioxide (NO_x) emissions caused by the shipping industry. Annex VI was adopted 26 September 1997 and entered into force 19 May 2005 the scope of Annex VI was to include a global cap of 4,5% sulphur content in fuel oil and calls for the IMO to observe the worldwide content of sulphur in marine fuel oil. Annex VI allows for special sulphur emission control areas SECA's where the content of sulphur in the fuel oil used must not exceed 1,5% . The alternative to a reduction of the sulphur content in the fuel oil is to fit an exhaust gas cleaning system or to use any other technical method to achieve the required emission level (imo.org, 2008₂).

1.6.4 MARPOL Annex VI revised.

In October 2008 IMO ratified far reaching revisions to MARPOL Annex VI the main changes was related to significant reductions in sulphur contents of fuel. This revised amendment will enter into force on July 1. 2010 (imo.org₂). The political pressure and the threat of more national regulations among countries resulted in an agreement more far reaching than many had expected (sustanebleshipping.com, 2008). The revised amendment has increased the focus on other shipping emissions like Particulate Matters (PM) and NO_x this will result in a name change in the stricter regulation areas, former SECA to ECA (Emission Control Area) in 2016, which from now on will be referred to as ECA's (Emission Control Areas.) The revised Annex VI has ambitious restrictions concerning the sulphur emissions in the following years.

Exhaust Gas Cleaning Systems (EGCS) and alternative technologies or fuels will be allowed to achieve the relevant emission reductions under the revised annex.

Table 1: Sulphur limits

Region	2010	2012	2015	2020
Global	4,50 %	3,50 %	-	0,50 %
ECA's	1,50 %	-	0,10 %	-

The table above shows the major changes concerning the sulphur emissions for the shipping industry, however IMO has opened for a review concerning the 2020 0,5 % global sulphur cap. This review will take place in 2018 and concerns low sulphur fuel availability. If the review concludes that the availability is not adequate, then the date will be set to January 2025 (sustanebleshipping.com, 2008).

This thesis will mainly focus on the change that will apply from Jan.2015 as this change will presumably increase bunker costs considerably for the shipping companies operating in the ECA areas. The stricter control areas are likely to expand within a few years, California, Canada and the Mediterranean are the first likely candidates to be included in the ECA areas that today include the North Sea, Baltic Sea, and the English Channel which is shown in the figure 3.

Figure 3: (Sulphur) Emission Control Area



2 Theoretical framework

2.1 Trade theory

Looking at the main trade routes and the characteristics of the cargoes traded between regions we find that the main characteristics of the commodities shipped in one direction are often quite different from of the commodities going the opposite way. Some of the reasons for this behavior can be found studying trade theory.

Shipping demand is derived from world economy which to a large extent depends on trade to grow. The reason why trade takes place is because somebody makes a profit from it. The profit is achievable because of differences in costs and technological development among countries, and if the cost savings are large enough to cover transport costs and tariffs, someone will capture this arbitrage opportunity and trade will take place (Stopford, 2009).

Some of the reason for the cost differences in factors of production between counties can be found looking at trade theory. One of the early theories concerning this subject was Adam Smith's theory of absolute advantage, which stated that counties which were more efficient in producing a product should specialize in the production of that commodity and export the produced surplus, while importing commodities the country did not have an advantage in producing. As long as the savings exceeded transport cost the specialized production would result in increased wealth and thus a higher demand for transport (Krugman,R,P. and Obstfeld, M.2006).

2.1.1 Comparative advantage

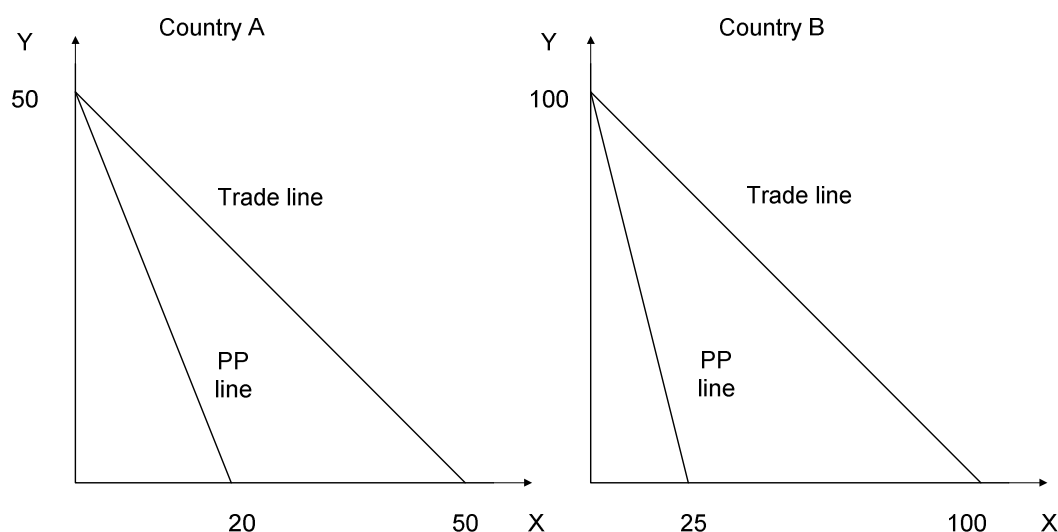
In 1817 David Ricardo published his trade theory emphasizing the importance of comparative advantage which stated that even if a country did not possess absolute advantage the trade could still be beneficial to both parties because limited factors of production are used more efficiently making all participants better off than they were before trade was initiated (Krugman,R,P. and Obstfeld, M.2006).

In practice it is hard to measure the impacts of comparative advantage on foreign trade directly. The reason for this is that the hypothesis is not especially suitable for empirical testing, but in theory it can be examined by a detailed study of a country's production possibilities (Norman, 1992).

Comparative advantage can be caused by differences in the production possibilities between countries, and they can arise by differences in the demand patterns between countries. This means that two countries with identical production possibilities can experience differences in the autarky price if the demand patterns differ between the two countries (Norman, 1992).

Comparative advantages can be explained based on differences in production possibilities, which can be caused by differences in technology. If it is assumed that two goods are produced (X and Y) with one production factor (labor) in countries A and B, and that labor's marginal product is held constant and equals the average product. For simplicity it is further assumed that the countries only have 100 hours available to produce the two goods. Country A has to use 5 and 2 hours to produce one unit of respectively X and Y, which means that country A can produce 20 units of X and 50 units of Y. While country B has to use 4 and 1 hour to produce one unit of respectively X and Y which means that country B can produce 25 units of X and 100 units of Y. This means that in this example country B has an absolute advantage in producing both goods but country A has the comparative advantage in producing X. This is demonstrated by the fact that in country B each unit of added output of X means the loss of 4 units of Y, whereas in country A 2,5 units of Y has to be given to obtain another unit of X. This means that the country that has the relative best technology will have a comparative advantage. The figure below illustrates how the countries will adapt when they are opened for trade.

Figure 4: Consumption Possibilities

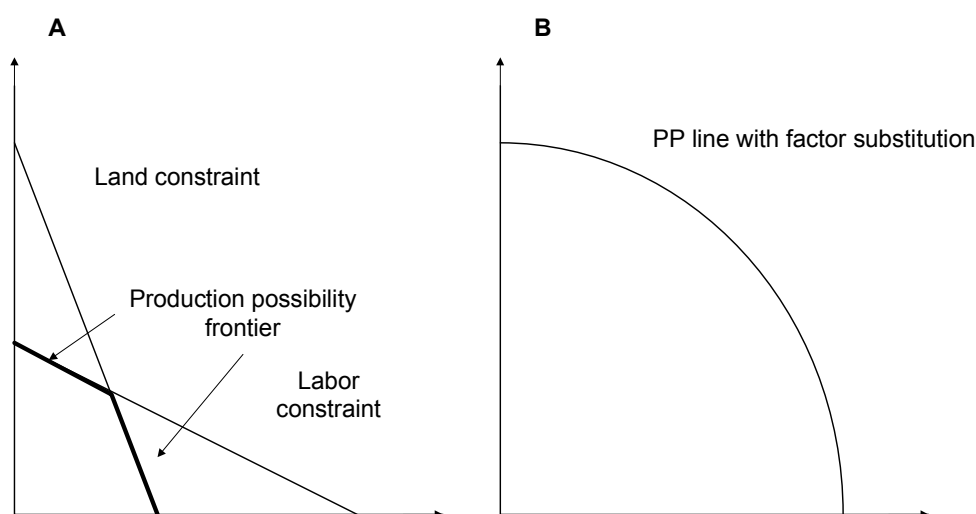


When the countries opens for trade they will fully specialize in each economy and both countries will adapt to the trade line. It can be seen by these lines that trade will be beneficial to both countries because all possible consumption possibilities lies above or are at least equal to what the countries are able to produce on their own. In this presentation the price of the goods is not determined as we have assumed that the terms of trade will be one to one, and that the countries possible consumption is given by the trade lines.

The example above with one production factor is useful for a theoretical approach but it is not especially credible in the real world. This means that the example can be expanded to include two factors. This approach is called “the model of a two factor economy” and is the simplest version of the factor proportions model (Krugman,R,P. and Obstfeld, M.2006).

In this example the two countries will be A and B, the two factors of production will be labor and land and the two goods will be food and cloth. First it is assumed that there is only one way of producing each good, this means that it takes a fixed amount of labor and land to produce one unit of food or cloth and that there will be no way of substituting land for labor or vice versa. These constraints would lead to the kinked production possibility frontier showed in panel A by the figure below (Krugman,R,P. and Obstfeld, M.2006).

Figure 5: Production Possibility Frontier



The kink is a result of the fact that the opportunity costs of producing an extra unit of cloth in terms of food is constant, which means that the opportunity costs of producing cloth in terms of food will rise as the economy's mix shifts towards cloth.

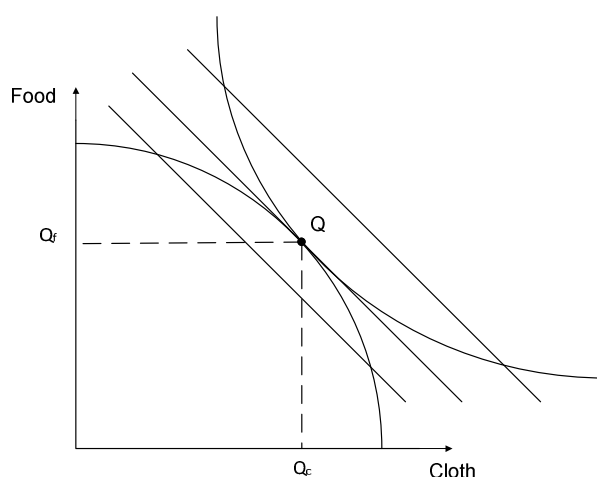
If we allow for the possibility of substituting land for labor and vice versa in production, the kink in the production possibility frontier (PP) will be removed, instead it will have a bow shape shown in panel B. This tells us as before that the opportunity costs of producing cloth instead of food rises as the economies production mix, shifts away from food. The slope of the PP line is called the marginal rate of transformation (MRT) and tells us about the relationship between the alternative costs concerning the two goods.

2.1.2 Autarky adoption

To find out where on the PP line the economy should produce we have to know the point where the economy maximizes the value of production. The value of production can be expressed mathematically in the following way: $V = P_c * Q_c + P_f * Q_f$ where P_c and P_f represents the price of cloth and food. This value will form an isovalue line, where the value of output always will remain constant but the factor proportions will fluctuate with the price of the factors used. This implies that the isovalue line has a slope of $\left(-\frac{p_c}{p_f}\right)$. If we take basis

in an autarky that is only inhabited by a single consumer, but organized like an economy of perfect competition, the production will take place as shown in the figure below.

Figure 6: Adoption In an autarky



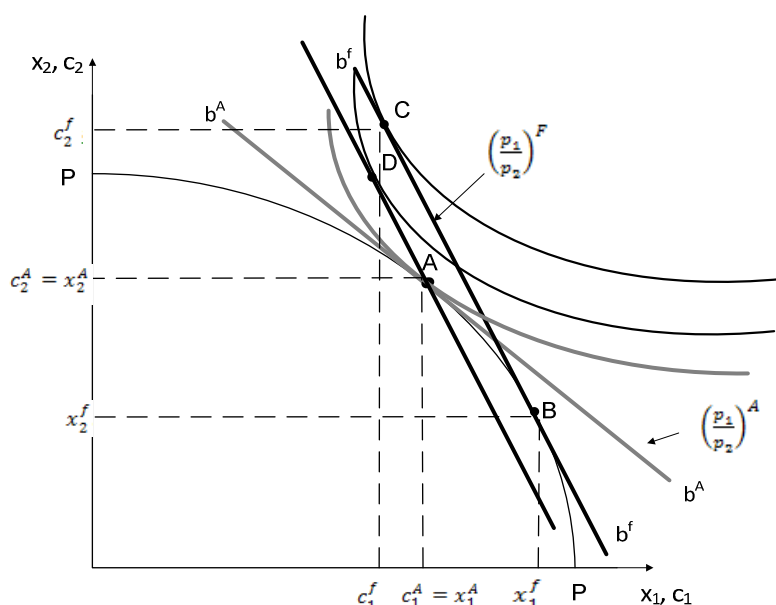
The production and consumer adoption will take place at the point where the PP curve and the indifference curve touches (Q) at the output of Q_c and Q_f of respectively cloth and food. The indifference curve states points where the consumers have the same utility, the slope of this curve is called marginal rate of substitution (MRS). The consumer's goal is to get to the highest possible indifference curve to maximize utility. The autarky will produce where the $MRS = MRT$ which is the combination of cloth and food that maximizes income, and also leads to a utility maximization for the consumers' in the economy.

2.1.3 Gains from trade

If the autarky opens up to free trade it will most probably face other prices due to comparative advantage between countries. The economy will still want to maximize its income and thus produce where the isovalue line touches the PP line. The price conditions will still be determined by the consumers' preferences, but now it will include the consumers' from the whole world. We can also assume that the autarky do not have the

necessary market power to change the international prices when it opens up. The figure below shows a case where an autarky opens up for trade and the effects this has on the two consumer products 1 and 2.

Figure 7: Autarky and free trade adoption



Source: Norman, V. D.: *Næringsstruktur og utenrikshandel i en liten åpen økonomi*. Oslo. Gyldendal Norsk Forlag 1993 s. 146

The point A in the figure above represents the autarky adoption as shown in figure 6 the price line $\left(\frac{p_1}{p_2}\right)^A$ also represents the consumers budget constraint b^A as the production income falls to the consumer. It is easy to observe that production equals consumption in point A $c_i^A = x_i^A$ because trade is not initiated. If the closed economy opens for trade with the world with a price level that differs from the one it had in the autarky the product and consumer adoption will change. In this case the international price conditions are $\left(\frac{p_1}{p_2}\right)^F$ which indicates that the price of good 1 compared to good 2 is higher than in the closed economy, hence the steeper price curve. This will lead to less production of good 2 and an increased production of good 1, leading to the production adoption in point B. The consumer

will obtain the budget line b^fb^f and adopt in point C, since he is disengaged from the production as a result of the free trade. The country will in this case export the surplus production of cloth, this amount is equivalent to the area between c_1^f and x_1^f . In order to cover food consumption it has to import the amount equivalent to the area between c_2^f and x_2^f .

Figure 7 shows clearly that there are gains to be made by opening up the economy; the consumer has increased his utility by reaching an indifference curve located higher than at the basis point A. The reason for this is that the consumption opportunities in an autarky are limited to the production possibilities (PP line), while with free trade the consumer can adopt along the b^fb^f line.

There are two reasons concerning this positive effect caused by free trade. If we assume that the production still is locked in the autarky position, but that we can open for free trade, the consumer will adopt in point D, which also represents a higher utility for the consumer since it is located on a higher indifference curve. The other utility profit is gained by the utilization of the comparative advantage that arises when production is changed from point A to point B. This means that the utility gain that arises between point D and C is due to comparative advantage (Norman, 1992). This means that the larger the difference in the relative price level is, the larger the gain from trade will be.

2.1.4 Hecksher and Ohlin

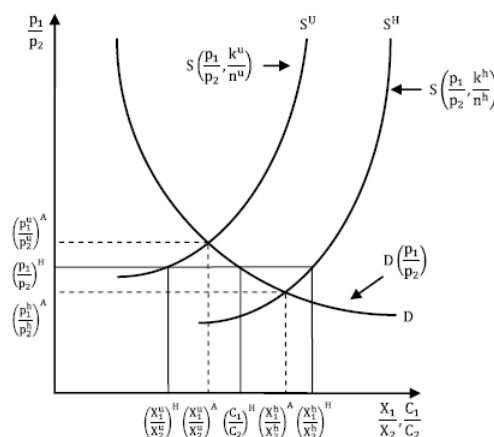
Freight demand can also be affected by how countries are endowed with different factors of production. Hecksher and Ohlin focused on this point when they developed there trade theory. The Hecksher/Ohlin model emphasizes the effectiveness of trading, when recourses are unequally distributed between counties. This theory goes a long way in explaining the diversity of today's trade between recourse rich and recourse poor countries (Stopford 2009).

The H/O model gives us further insight into what factors that induce comparative advantages between countries. The basic model assumes that there exist two countries (h and u) two factors of production (labor and capital), and two goods (one labor-intensive, and one capital-intensive). Further assumptions that are made is, the absence of transaction costs, and that the factors of production cannot be traded internationally but can freely move between industries in one country. Country h and u have to have the same technologies of production as well as identical demand functions (Norman 1992).

These assumptions have now led us to the production and consumption of the two goods respectively (x_i^h, c_i^h) and (x_i^u, c_i^u) with the international price level of p_i . Further we will have the following access to the factor inputs (n^h, k^h) and (n^u, k^u) with the following factor prices (w^h, r^h) and (w^u, r^u) . In addition to this it can be assumed that goods 1 is capital intensive and goods 2 are labor intensive, and that country h is relatively better endowed with capital; hence $(k^h/n^h) > (k^u/n^u)$ (Norman 1992).

Based on these assumptions we will now be interested in finding out how differences in the countries relative factor endowments will affect production and trade in a case of perfect competitive equilibrium with free trade, and how trade will affect the remuneration of the input factors.

Figure 8: Heckscher and Ohlin theory



Source: Norman, V. D.: *Næringsstruktur og utenrikshandel i en liten åpen økonomi*. Oslo.

Gyldendal Norsk Forlag 1993 s. 164

This example shows that the relative demand in both countries is represented by the DD-curve, we can further observe the relative supply curve in country u and h that is represented with the s^u and s^h curves in that order. The demand curve slopes downwards due to the fact that the demand decreases relative to the increasing price of the goods in question, and the supply curves are increasing because of the relative increased production caused by the relative increase in the price of the goods (Norman 1992).

We can see that with an autarky adoption the economies would produce and consume where the supply and demand curves intercept. This means that the autarky adoption would lead to a production of $\left(\frac{x_1^h}{x_2^h}\right)^A$ at the price $\left(\frac{p_1^h}{p_2^h}\right)^A$ in country h, and a production of $\left(\frac{x_1^u}{x_2^u}\right)^A$ at the price of $\left(\frac{p_1^u}{p_2^u}\right)^A$ in country u. This would consequently lead to the same consumption levels in accordance to the explanation of autarky in chapter 2.1.2.

If the countries opens up for free trade they will experience a change in the price level of the two goods, this is illustrated by the new interception point on the demand curve located between the previous two adoption points. The new market price will be $\left(\frac{p_1}{p_2}\right)^H$ which will lead to the following relative demand in both countries $\left(\frac{c_1}{c_2}\right)^H$, while country h will produce $\left(\frac{x_1^h}{x_2^h}\right)^H$ and country u will produce at $\left(\frac{x_1^u}{x_2^u}\right)^H$. This means that country h will export the capital intensive goods and import the labor intensive goods, represented with the following relationship (Norman 1992): $\left(\frac{x_1^h}{x_2^h}\right)^H > \left(\frac{c_1}{c_2}\right)^H$.

If we assume that country h has relatively more capital than country u, but country u is relatively more endowed with labor, it would be natural to suppose that capital in an autarky would be relatively cheaper in country h but labor would be relatively cheaper in country u. If we denote the capital costs (rates) with r and, labor costs (wage) with w , this relationship can be represented in the following way: $\left(\frac{w^h}{r^h}\right)^A > \left(\frac{w^u}{r^u}\right)^A$. If the countries open for free trade it will lead to a situation where country h will transfer resources away from the labor intensive goods to produce the capital intensive goods, and that country u will transfer resources away from the capital intensive goods to the labor intensive goods, and in this way

exploit the comparative advantages. This behavior will lead to a scarcity of the capital in country h and labor in country u because of the increased pressure on the factors of production, thus leading to an increased price of capital in country h and labor in country u. Hence $\left(\frac{w^h}{r^h}\right)$ will fall and $\left(\frac{w^u}{r^u}\right)$ will rise which will lead to a leveling out of the factor prices between the countries. This behavior is known as the factor price equalization theorem (Norman, 1992).

This theorem has been subjected to some ill dispute over the years, the reason for this is the fact that it depends on quite strict assumptions: Free trade, no transport costs, identical technology with constant returns to scale, at least as many purchased goods as non purchased factor inputs, and no specialization (Norman, 1992).

These assumptions have led the theorem to be regarded as a theoretical curiosum that lacks relations with reality. This has seemed to be a premature conclusion, as empirical data has shown that international factor price differences in fact have been reduced due to international trade. In addition to this the theorem can be used to illustrate the problems where the assumptions do not hold.

2.3 Partial equilibrium in competitive markets

Shipping is a business that is generally determined by perfect competition or competitive market (Stopford, 2009). This means that when the number of firms in the market rises the firms will act more competitively until marginal costs equals marginal revenue (Francois and Wooton, 2001). The following definition is commonly used for competitive behavior: “A buyer or a seller is said to be competitive if the agent assumes or believes that the market price is given and that the agent’s actions do not influence the market price” (Shy 1995 p.63).

Other market distinctions related to a competitive market are:

- Homogenous products.
- Perfect information
- Free entry exit
- No externalities

To explain how transport supply and demand are determined we need to look at the basic partial equilibrium model and the way different conditions determine the quantity supplied and demanded and thus the clearing price. The partial equilibrium model use variables given inside the model (endogenous), to isolate the considered good from outside (exogenous) variables like general prices on substitutes and complementary goods. We can normally say that in an equilibrium model the endogenous variables are determined by the exogenous, but in a case where the exogenous variables do not correlate strongly with the other variables we can choose to use the partial equilibrium model for simplicity (Varian, 2006).

2.3.1 Demand

To get an understanding of how the consumer relates to the price and quantity of it is essential to look at the demand function, which can be expressed in the following way:

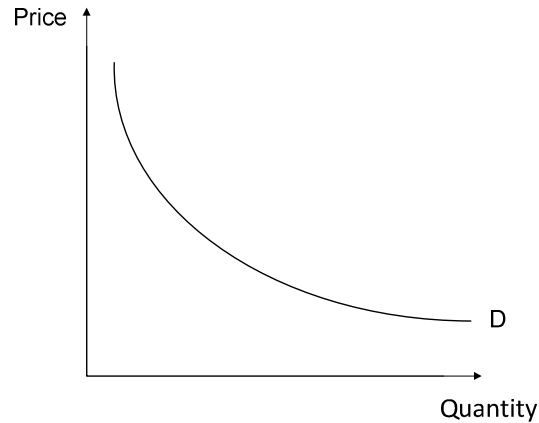
$D(p)=q(I,P)$ where $D(p)$ represents the planned demand at price p . And $q(I, P)$ represents the Marshallian demand function.

The assumptions that need to be taken are:

- $q > 0$ and $p > 0$
- The following holds with respect to $D(p)$:
 1. D : Price: $(0, \infty) \rightarrow$ Amount: $[0, \infty)$
 2. $\frac{d D(p)}{dp} < 0$

These characteristics are shown in the figure below:

Figure 9: Demand curve



This figure shows a typical demand curve where declining prices result in a higher quantity demanded. The slope of the demand function $D(p)$ tells us how responsive the demand is to a change in the price. The slope of the demand function is expressed in this way: $-\frac{\Delta q}{\Delta p}$

This is a measure of responsiveness but it presents a problem regarding the measurement of the units in question, this is why it has to be converted to a unit free measurement known as elasticity. In this case it is necessary to look at the price elasticity of demand which expresses the percent change in quantity divided by the percent change in price. This is expressed mathematically by the following formula (Varian, 2006):

$$\epsilon_d = \frac{\Delta q/q}{\Delta p/p}.$$

If the price elasticity is high a change in price will have a greater impact on the demanded quantity than if the price elasticity is low. Generally necessary goods like fuel and toothpaste will have low price elasticity while luxury goods like cars and boats will have high price elasticity.

Another significant factor that has an effect on the demanded quantity of a product is the income of the consumer that demands the commodity in question. A measure that is used to

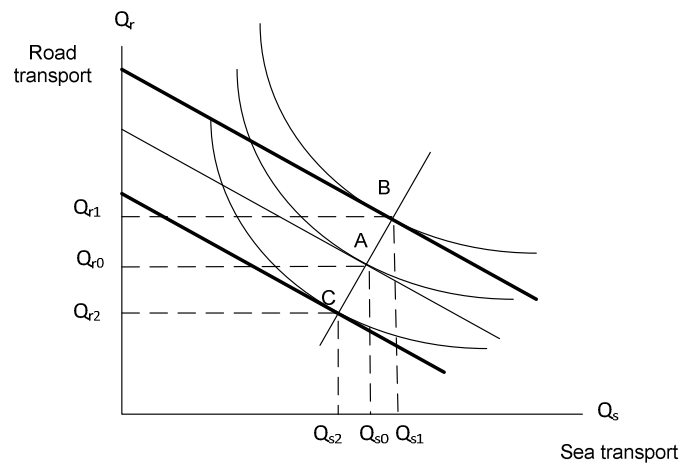
explore the effect a change in income has on the demand for the final product is called income elasticity of demand and is expressed mathematically in the following way (Pindyck and Rubinfeld 2005):

$$\varepsilon_I = \frac{\Delta Q/Q}{\Delta I/I} = \frac{I}{Q} \frac{\Delta Q}{\Delta I}$$

Where Q represents the quantity the consumer demands of a certain commodity and I represent the income. This equation states how much the demand will change as a result of a 1 percent change in income.

The income effects distributed between two normal goods can be expressed graphically in the following way:

Figure 10: Income effect



The figure shows a consumer that starts off with a given income level and adopts in point A where the indifference curve touches the budget line leading to a consumption of Q_{r1} of goods one and Q_{s1} of goods two. If the relative income goes up the consumption of the two commodities increases leading the consumer to adopt in point B and if the relative income decreases the consumption will decline to Q_{r2} for goods one and Q_{s2} for goods 2. An income change can affect the demanded quantity of each goods differently depending on the

income elasticity of demand facing each good, with a positive income elasticity of demand the goods are described as normal, and the consumer will consequently buy more of both goods in the case of a income increase and vice versa. If the goods are faced with a negative income elasticity of demand the consumer will buy less of the product as his income rises, these goods are described as inferior goods (Varian, 2006).

2.3.2 Supply

The supply of any goods will undoubtedly depend on the suppliers costs. There are three elements that distinguish the performance of a shipping company (Stopford, 1997):

- The revenue received from chartering/operating ships
- The cost of running the ship
- The method of financing the business

The shipping company's management has to some degree; the ability to adapt the company's cost structure. An example of this is the possibility to adjust the age of the fleet as older ships are less capital intensive but have higher operating costs. The size of the ships is also a concern to the management as the cost structure and usability of the ships differ according to size. The shipping company's revenue can also be affected by the way it has financed its ships and in what market they operate.

For the supply function $S(p)$ the assumptions are:

1. S : Price: $(0, \infty) \rightarrow$ Amount: $[0, \infty)$
2. $\frac{dS(p)}{dp} > 0$

Interpretation:

- The supply function assigns an amount to each price.
- $S(p)$: = Planned supply given price level p .

In a case where there does not exist any substitution effects between input factors, the variable costs $C_v(q)$ will only be affected by the quantity supplied (q). Fixed costs (F) which are not affected by the supplied quantity will, together with the variable cost function, form the total cost function which is expressed in the following way: $TC(q) = C(q) = F + C_v(q)$.

The average cost function is determined by the ratio of the total production cost level, and is expressed in the following way (Varian, 2006):

$$AC(q) = \frac{TC(q)}{q} = \frac{F}{q} + \frac{C_v(q)}{q}.$$

As we can see the variable costs and fixed costs are divided by the quantity produced, this results in decreasing fixed costs per unit produced. The variable average cost will in the beginning of production, at worst grow proportionally with the production output. When the effects of the two cost functions is combined, the AC curve will at first start to decline due to a decrease in the fixed average costs. When the fixed factors eventually constrain the supply due to capacity constraint, for example related to a production plants size, will average variable costs and thus marginal costs begin to increase causing a U shaped AC curve (Varian 2006).

The marginal cost function shows us how large the change in total costs will be as a result of a small increase in output levels and can be expressed in the following way (Varian, 2006):

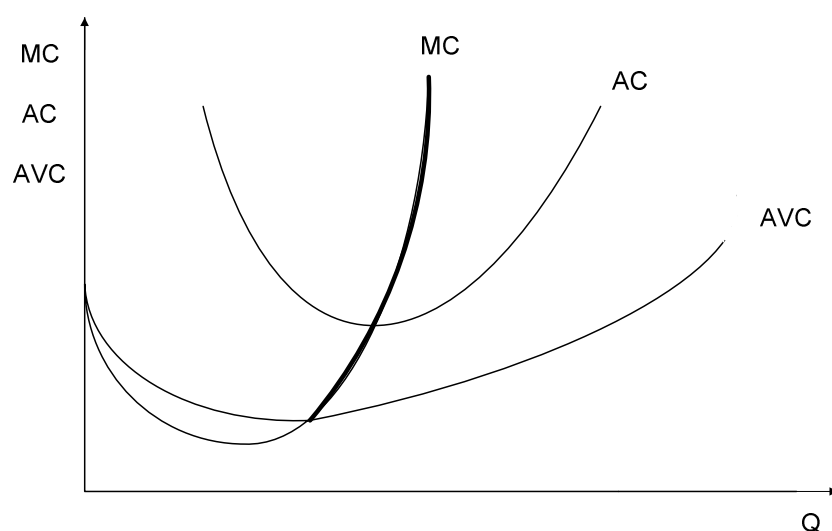
$$MC = \frac{dC(q)}{dq} = \frac{F}{dq} + \frac{dC_v(q)}{dq} = \frac{dC_v(q)}{dq}$$

It can be seen from the equation that the fixed cost does not change as the quantity produced changes (Varian, 2006).

A competitive firm ignores its influence on the market price and it has to maximize its profits, which is the difference between revenue pq and costs $C(q)$. This is done by operating where the marginal costs equals marginal revenue, this means that the extra revenue the firm gains by producing one more unit, just equals the extra cost of producing an additional

unit, which means that in the case of competitive firms; marginal revenue equals market price.

Figur 11: Cost curves



Source: Varian, H. R.: *Intermediate Microeconomics: A modern Approach*, 7nd Ed.
New York, USA: W. W. Norton & Company, 2006.

As it can be seen from the figure above the average variable cost curve and marginal cost curve starts out at the same point. After that the MC curve declines faster than AVC curve because MC does not include fixed costs. The AVC and AC curves turn upward again (rise) when MC is equal to AVC and AC. This is because of the production constraints caused by the fixed factors.

As mentioned every rational player with profit maximizing behavior will produce until the price of the last unit supplied equals marginal costs. If the costs per unit are higher than the price, the firm will have to reduce the output until $p=MC$. But if the market price does not surpass the AVC in the short run, the firm will lose money and shut down, leaving the producers with a lower cost structure in the market. In the long run firms have to cover their fixed costs as well. This means that in the short run the supply curve will be exactly the same

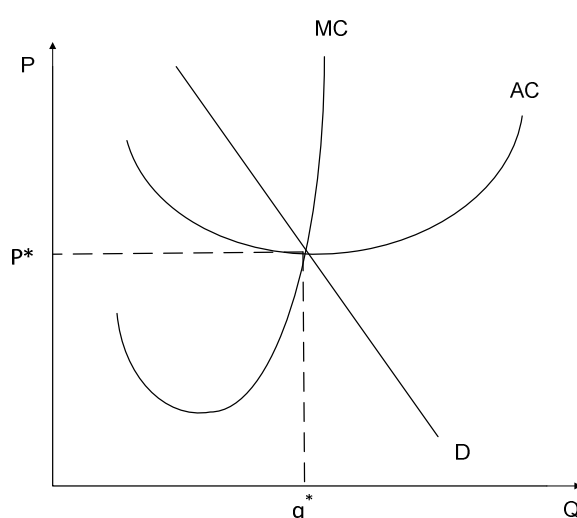
as the part of the marginal cost curve that lies above the AVC curve. This means that the market price will be equal to marginal cost (Varian, H. R 2006).

The price elasticity of supply is defined in a similar manner as the price elasticity of demand $\epsilon_s = \frac{\Delta q/q}{\Delta p/p}$ and measures the sensitivity of the industry output to market price, this measure will always be positive in the short run due to the upward sloping marginal cost curve (Pindyck, R and Rubinfeld, R 2005). The elasticity will become less elastic as the marginal costs increases, which can be observed in the example shown in figure 11.

2.3.3 Market equilibrium

If there exist a number of consumers of goods, and we add all these individual demands we will get the markets aggregated demand curve. The same applies to the producers of the goods ore service in question, which adds up to the markets aggregated supply curve. Since each market contender is a small part of the competitive-market as a whole they can not affect the market price in any way, but it is the actions of all the agents together that decide the market price and the quantity supplied.

Figure 12: Market adoption with free trade



The figure above shows the equilibrium price (P^*) of a commodity and the supplied equilibrium quantity (q^*). This is the point where the supply of the goods equals demand and where all the participants choose the best possible action for themselves. If the price differs from the equilibrium price, some agent's actions would be unable to be realized, and they would have an incentive to change their behavior. This means that if a price is not an equilibrium price it will not exist in the long run due to the agent's incentive to change their actions. It has to be noted that this competitive equilibrium only exists where there are constant returns to scale technology this means that fixed costs doesn't exist ($F=0$).

2.4 Scale economies

Since constant returns to scale in the long run in a competitive market is more suited for theory, it is important to take a look at what happens to the fixed factors in the long run and what implications this will have for the long term average costs and thus the marginal costs and the supplied quantity. In the long run all factors can be changed, and if a firm doubles its inputs and more than doubles its outputs we can say that it has increasing returns to scale technologies.

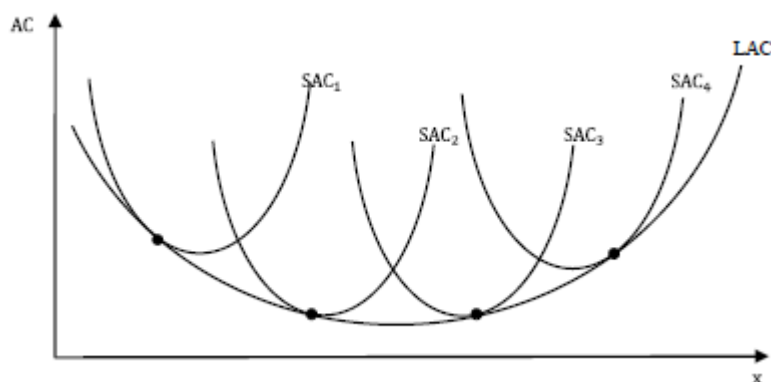
In the shipping industry increasing returns to scale can be generated as the ships grow; the reason for this is that the costs do not necessarily increase proportionally with the transport capacity of the ship. There are three elements that stand out as the main essentials affecting economies of scale in liner shipping industry; these are capital costs, operating expenses and bunker costs (Stopford, 2009).

To show this relationship we can think of the fixed factor as to be the ships size (k), and then the long run would be defined as the time it would take to change the size of the ship. This is a fairly short time in shipping as ships are movable capital unlike a plant on land and can be sold and bought on the second-hand market. If a new ship has to be purposely built the time span would increase considerably.

The firms short run cost function, given the capacity of the ship (TEU), will be denoted by $C_s(y, k)$. For any level of transport supply there will be a ship size that is optimal. This

relationship is denoted by $k(y)$. This means that the long run cost function will thus be $C(y) = C_s(y, k(y))$ and interprets the optimal choice of the fixed factors.

Figure 13: Short & long-term average cost curves



Source: Varian, H. R.: *Intermediate Microeconomics: A modern Approach*, 7nd Ed.
New York, USA: W. W. Norton & Company, 2006. P 377.

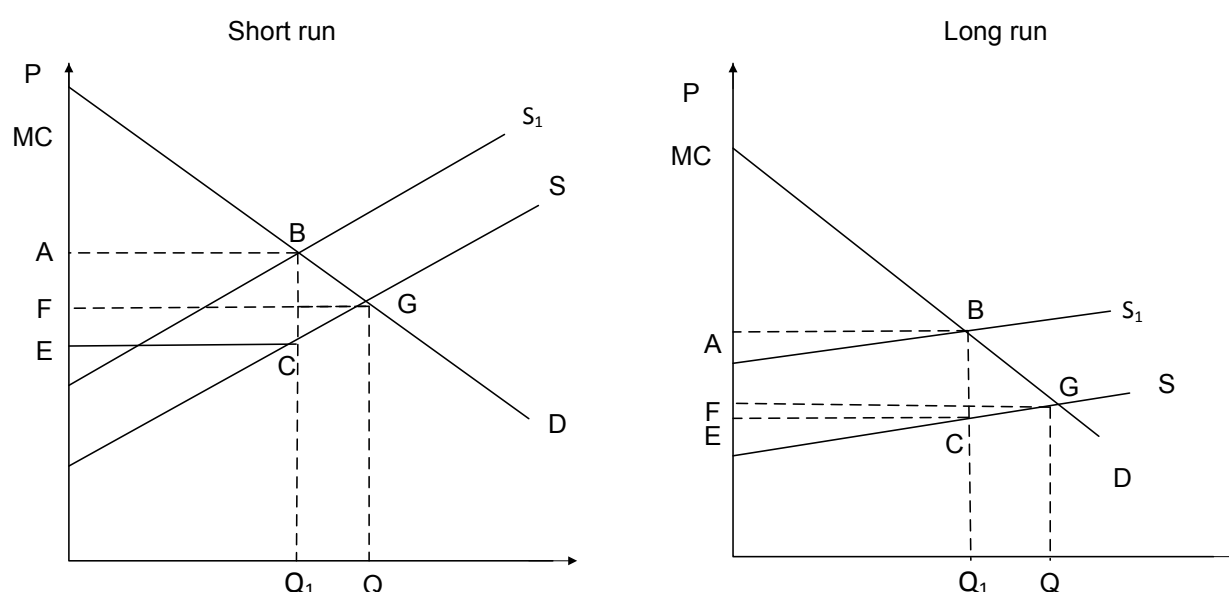
The graph above shows a case where a firm has increasing returns to scale in the cases between the short run average cost curves SAC_1 and SAC_2 . Constant returns to scale between SAC_2 and SAC_3 , and decreasing returns to scale between SAC_3 and SAC_4 . This makes the long run average cost curve U shaped. We can see that the short run costs are always greater than the long run costs except at the point that they touch the long run average cost curve this implies that: $AC_L \leq AC_s$. The reason for this is the increased freedom related to the firm's cost structure.

2.4.1 Short & long run supply curve

When explaining the effects of cost changes it is essential to distinguish between short and long run costs of the firm. A change in the firm's costs will usually have different impacts on the firm, depending on the time horizon in question. Some of the reasons for this are explained in the chapter above; however, the author wishes to explain this relationship in a supply demand context. The reason for this is to clarify the effects of a cost increase and consequently a supply decrease, which affects the producer surplus adversely.

The producer surplus is closely related to profit but not identical to it, the difference is the element of fixed cost which is not included when calculating producer surplus, meaning that the producer surplus is represented by the difference between the market price of the product and the marginal costs. The figure below shows the relationship between the short and long run supply curve.

Figure 14: Short & long run supply curve



The panel to the left in the figure above illustrates a situation where the marginal costs increase, hence making the supply curve shift upwards to S_1 and a reduction in output from Q to Q_1 . This reduces the producer surplus with the area represented with $FGEC$ and the consumer surplus with the area represented by $FGBA$. As explained in the previous chapter, the inputs are fixed in the short run; this limits the flexibility of the firm to adapt its outputs to new technological developments or to adjust its scale of operation. However, in the longer run a company can adjust all its inputs, including ship size. This feature of the long run cost structure tends to make the long run supply curve more elastic (Varian, H. R. 2006). This characteristic is shown in the panel on the right side of figure 14, where the supply curves are nearly perfectly elastic making the loss of producer surplus ($FGEC$) considerably less than

in the short run. This is done on the expense of the consumer surplus (FGBA), meaning that in the longer run the increased costs will to a greater extent be compensated by the consumer as the firm adapts to the new cost situation.

2.5 Market structure in liner shipping

As mentioned earlier the shipping market is, in general, known as a highly competitive market. Some of the reasons for this are because the ships are movable capital which makes it easy for the ship owners to enter and exit a market fairly easily (Sjøstrøm, w.2002). The shipping market is also known for well informed players, homogenous products, and transport of various cargoes. These features help sharpen the competitiveness of the business. However, the liner service is in a somewhat unique situation when it comes to price taking behavior, the reason for this is the fixed costs related to the obligations of a fixed service. While bulk companies can lay up ships in bad times to save costs, liner companies have to obtain their original sailing schedule even if the rates do not cover marginal costs (Stopford, 2009). This is a cause of great concern to the liner companies which can result in fixed price regimes to get a more even cash flow. This behavior does not support the behavior of a competitive market, but it helps price stability (Stopford, 2009).

2.5.1 Liner conferences & alliances

As explained above the liner market is exposed to great fluctuations in freight rates because of trade cycles, seasonal cycles and trade imbalances. Over the years, this volatility has led to a cooperative trend between liner companies. The first conference system was developed in the mid 1870's to ensure that freight rates would cover average costs on the route from United Kingdom to Calcutta (Stopford, 2009).

Because of general disapproval from the regulatory authorities, the conference system faded out by the late 1980 and global alliances were set up instead. In the mid 1990's about 60% of the liner capacity on the major routes was in some way connected to an alliance such as the Transpacific Stabilisation Agreement (TSA) (Stopford, 2009).

Beside the intention to stabilize freight rates through market stabilization strategies, liner shipping companies can enter into cooperative strategies for other motives, like service differentiation strategies, cost reduction strategies and market development strategies. All of these business strategies have the aim of using cooperation to enhance their firm's competitiveness and cash flow stability (Ryoo, D-K. and Lee, T-W 2002).

Cartel activity is generally regulated in other business markets because it puts the buyer/shipper in an adverse situation due to higher costs created by the cartels ability to adjust the capacity and thus not be a price taker (Milgrom, p. and Roberts, j. 1992).

The liner industry has found itself in an extraordinary situation in over 100 years now due to the legislative acceptance of conferences. Even in the early 1900 there were concerns involving liner conferences, but it was concluded that cooperation was necessary in order to keep the regularity of sailings and improve quality of ships (Gardner, B Et al. 2002).

This reasoning has to some degree stuck with the lawmaking authorities, although in the recent time shipping conferences have been subjected to stricter rules within EU (Stopford 2009).

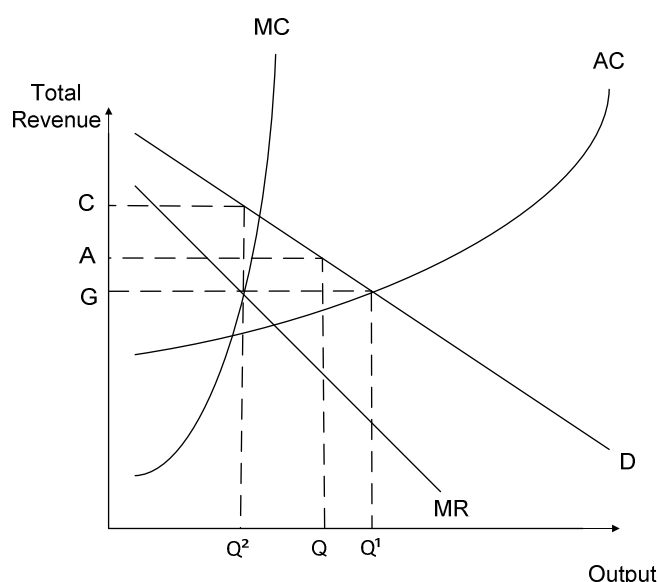
Even with a regulating framework concerning conferences in liner shipping, strategic conduct can still occur in the form of implicit agreements between the players to restrict their supply of transport (Stopford, 2009); this implies that at least one of the assumptions concerning competitive markets cannot hold. This will lead to a loss of social welfare as the recourses will not be allocated as efficiently as with marginal cost pricing. The most relevant cases of strategic conduct related to the liner industry, is the fact that there are often few transport providers on a route, discriminating behavior occurs concerning freight pricing and the cost differences between firms due to cost reduction strategies.

2.5.2 Few transport providers

In the case of cartel like activity or monopolistic behavior on a trade route, the shipping company will have greater power to adopt its supply and thus adjust the price level on transport on that specific route. This will generate larger profits to the monopolist which in turn can encourage new entrants to compete (McConville, 1999).

The monopolist's average revenue is precisely the market demand curve. The monopolist has to know its marginal revenue to choose its profit maximizing output level. When the marginal revenue is known it is evident that in the case of positive marginal revenue the revenue is increasing with quantity and vice versa. The demand curve and marginal revenue functions will have the same vertical intercepts; however the marginal revenue function is twice as steep. These characteristics are shown in the figure below.

Figure 15: Shipping conferences & freight rates



Source: McConville, J.: *Economics of maritime transport: Theory and practice*, 1. Ed. London: Witherby Publisher 1999, 360.

It can be seen from the figure above that the profit maximizing output for a rational monopolist would be at the point Q^2 at the revenue level C . This is the level where $MC=MR$ which indicates a monopoly profit, will encourage competition as the prices are higher than MC ($P > MC$). The profit compared to a market with perfect competition will be the difference between the point where $MR = MC$ and the demand curve. In a competitive market the quantity supplied would be Q^1 resulting in the revenue level at point G which just covers AC . At this price level a market entry will not be profitable for new entrants and there

will be no new entries, but the profit for the monopolist will be negligible. This fact means that agents with monopoly power have to look beyond the short term temptation of making larger profits in good times to ensure that competitors will not enter the market and push down profits in the long run. This will lead the monopolist to supply a quantity between the two extremities Q^2 and Q^1 which in this case will be at the point Q at the price A and does not aim for maximum profits.

2.6 Discrimination and differentiation

The assumption used so far is that a monopolist will apply the same rate for all outputs but since liner companies have a lot of different customers per voyage it can be tempting to discriminate the shippers as some high value commodities can bear the costs better than low value commodities. Customers using liner services can also find themselves being discriminated according to their size as large firms have an advantage in negotiating freight rates. Another form of price discrimination can be induced by the fact that shippers have different requirements to the level of quality and service they want from their sea transport suppliers; this introduces an element of product differentiation (Stopford, 2009).

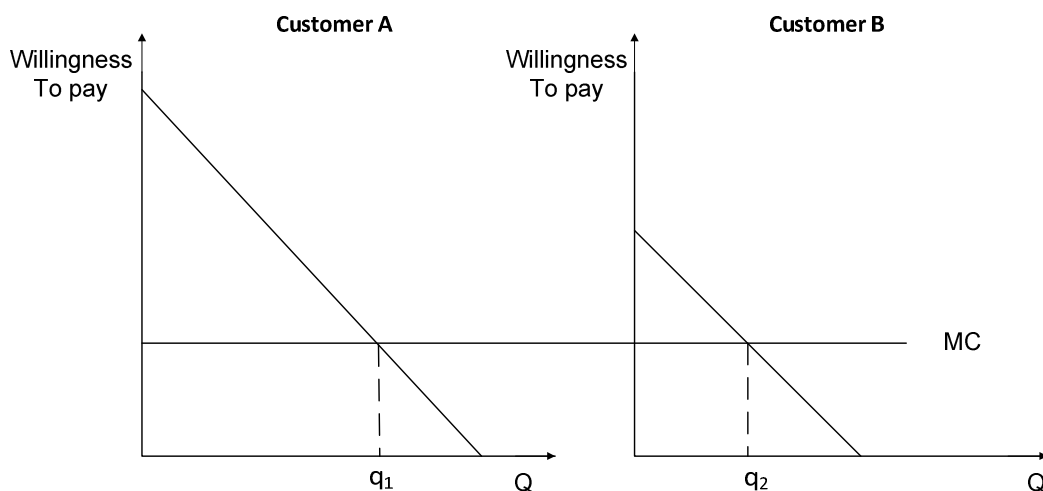
The service requirements fluctuate based on different price elasticity's on the commodities traded, as the shipper of a high value commodity are likely to pay more to get a "tailor made" transport service and to be assured on-time delivery. The four main aspects contributing to the service level provided by the liner company is: Price, speed reliability and Security (Stopford, 2009).

This behavior is possible because the markets are discrete and the fares only apply to a particular shipper. This price setting strategy can generate extra revenue because the firm will also be able to include the shippers who are only willing to ship goods at a discounted freight rate, and as long as this rate covers marginal costs it can be beneficial to offer discounted freight rates (McConville, 1999).

2.6.1 First degree price discrimination

Under this price setting regime, also referred to as perfect price discrimination, the company will set a price according to how much the buyer values it. This is represented in the figure below where the demand curve represents a change in the willingness to pay for an additional unit of the goods and the marginal cost is set to be constant. The producer will maximize profits by producing where the price equals marginal cost. This means that the firm will offer q_1 to customer A and to customer 2.

Figure 16: First degree price discrimination



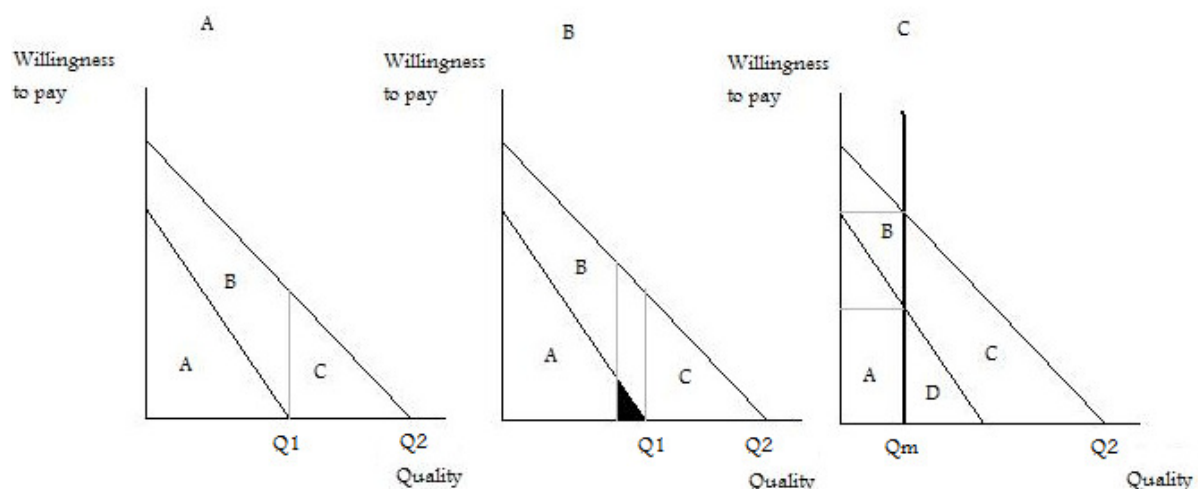
A company that is able to perfectly discriminate its customers will sell each unit at the highest price possible, which is at each consumer's reservation price. When this price regime is followed, a consumer surplus will not be generated, and the monopolist will appropriate this surplus to itself resulting in the maximum possible level of producer surplus. This means that this behavior will be Pareto efficient, as there will be no way to make the consumer's better off without reducing the producer's profit.

Because of the large numbers of customers a liner company handles in a year, this way of price discrimination would probably represent too much effort for the firm, and is generally just known as a theoretical concept (Varian 2006).

2.6.2 Second degree price discrimination

This price regime is also known as non linear pricing because the price per unit depends on how much you buy resulting in a non constant price per unit (Varian 2006). This form of price discrimination is more widespread in liner shipping due to the problems related to providing customer services to every shipper on the market as we get in the case of perfect price discrimination. With this price regime the liner company would like to offer two different price-quality packages on the market. One that is targeted towards the high requirement shipper and one targeted towards the low demand person. In this way the monopolist will try to induce the costumers to choose the packages meant for them giving them an incentive to self select, this behavior is illustrated in the figure below.

Figure 17: Second degree price discrimination



Panel A illustrates a situation where the monopolist can offer Q_1 to customer 1 at the price A and to offer Q_2 to customer 2 to price A+B+C. This combination would capture all surplus for the monopolist and reflects perfect price discrimination, but it is not compatible with self selection because the high requirement customer would choose the quality level Q_1 and pay price A, resulting in the surplus area B, this is better than zero surplus which he would get by choosing Q_2 . The monopolist can also decide to supply the level Q_2 at the price A+C, at this level the high requirement customer would find it optimal to choose this point and will be

receiving a gross surplus of $A+B+C$, but since he pays the monopolist $A+C$ his net surplus would yield B .

It can be seen from panel B that the monopolist also has a choice to offer a quality slightly less than Q_1 at a price slightly below A , this would reduce the monopolists profits by the triangle D , but since the quality level of this package is less attractive to the high requirement customer, the monopolist can charge him for the quality level Q_2 this strategy would make area A slightly smaller but makes the area C relatively bigger resulting in the net result of increased profits for the monopolist. Following this thought protocol, the monopolist wants to find the level where the profits lost on a quality reduction offered to the low requirement costumer equals the profits gained on the high requirement costumer, this will lead to a balance between the marginal costs and benefits of a quality reduction. This is illustrated in panel C where we see that the low requirement shipper will choose Q_m and is charged A and will end up with zero surplus, while the costumer that requires high quality transport will choose Q_2 and will be charged $A+B+C$ ending up with a surplus of B .

2.6.3 Third degree price discrimination

The cargoes shipped in containers are basically anything that can fit in a container. This means that the container industry is in competition with bulk shipping for minor bulk cargoes and lower value cargoes, which help liner services fill up the ships on legs with low transport demand. These “bottom cargoes” usually pay less than high value manufactured goods like auto parts, consumer electronics and textiles due to a lower value of transport-cost ratio, making low value cargoes, like lumber and scrap metal, more price elastic than high value cargo (Stopford, 2009).

In these cases the monopolist has to identify the different groups in order to adjust its price level according to the shipper’s price elasticity. If we use $P_1(x_1)$ and $P_2(x_2)$ to denote the inverse demand curves of costumer group 1 and 2, we can let $c(x_1 + x_2)$ represent the cost of the transport supply. Then the monopolist will face the following profit maximizing problem:

$$\text{Max } P_1(x_1)x_1 + P_2(x_2)x_2 - c(x_1 + x_2).$$

Then the optimal solution must be:

$$MR_1(x_1) = MC(x_1 + x_2)$$

$$MR_2(x_1) = MC(x_1 + x_2)$$

This means that the marginal cost of transporting one extra container must be equal to the marginal revenue in both markets. If MR in market 1 exceeds MC it would be beneficial for the company to expand its transport supply in market 1, this also applies to market 2.

Since the marginal cost is the same in both markets the marginal revenue also has to be the same. This implies that the goods should generate the same increase in revenue independent of which market it is sold (Varian 2006).

This pricing regime will lead to a higher price offered to the shippers with lower elasticity of demand, consequently charging the costumers with high price sensitivity a lower price. This behavior will lead to profit maximization for the liner company especially when on legs with available transport capacity.

2.7 Externalities in shipping

The shipping industry is subjected to several external costs related to the environment. The one in the center of this thesis is the negative welfare effects caused by SO₂ gasses emitted by the shipping industry. The nature of externalities is that they are not regulated by the system of prices. This may result in inefficiency related to externality-bearing activities (Milgrom, p. and Roberts, j. 1992).

The goal of environmental regulations is to ensure that the right decisions are made to allow the overall long term surplus for a society to be maximized. The most prominent problem related to the issue of externalities is the lack of property rights, which means that the entire cost of transport is not paid by the shipping company, seeing as the environmental cost is paid by the customers in the form of acid rain and health problems. This in turn means that if the property rights were defined and accepted to a greater extent, the market would have an easier task of solving these problems between the market participants in the form of

internalizing the costs caused by the externalities (Varian 2006). Without clear property rights the most probable outcome is government intervention to prevent pollution. These interventions are often in the form of obligatory environmental taxes, or as in this thesis in the form of imposed regulations concerning fuel quality, which in turn will increase the internal costs in the same way as taxes, due to an increase in the shipping industry's fuel costs.

There are various approaches to regulate the problems regarding negative externalities; the most direct approach is an environmental-political policy which involves prohibition, legislations and emission requirements (Minsaas, a. Et.al 2000), the negative effects relating to this method is the matter of accuracy, as these regulations can be subjected to subjective judgments, bureaucracy and political influence (Ma, s.2002). Secondly market based instruments are also widely used in order to control emissions, these instruments can include; indirect taxes, direct taxes, emission permits and subsidies. However in the latter time the emission control regimes has moved more and more towards a "consensus regime" where voluntary agreements and the industry's ability to self regulate becomes more important; examples of this kinds of emission regulating instruments are; voluntary agreements, environmental labeling, environmental standards, and green auditing (Minsaas, a. Et.al 2000).

2.7.1 Externalities in a free market

Consider a situation where a shipping company (S) provides a certain amount of transport and also produces a certain amount of pollution (x), which goes into the atmosphere in the form of sulphur oxide and adversely affects the farmer's production of corn (F) due to increased amounts of acid rain. If we suppose that the shipping company's cost function is given by $c_s(t, x)$, where t is the amount of transport provided and x represents the pollution caused by the transport, we can further denote the farmers cost function by $c_f(k, x)$ where k indicates the production of corn and x is the amount of pollution. In this case the costs related to the farmers production of corn depends on the pollution level of the shipping company. This means that increased pollution increases the costs of providing corn $\Delta c_f / \Delta x > 0$ but it decreases the cost of transport $\Delta c_s / \Delta x < 0$. The shipping firms profit maximization

problem will be $\max p_s t - c_s(t, x)$ and the farmers profit maximization problem will be:
 $\max p_f k - c_f(k, x)$.

The conditions that determine the shipping company's profit maximization will be:

$$P_s = \frac{\Delta c_s(t^*, x^*)}{\Delta s}$$

$$0 = \frac{\Delta c_s(t^*, x^*)}{\Delta x}$$

And for the farmer:

$$P_f = \frac{\Delta c_f(k^*, x^*)}{\Delta k}$$

These conditions tell us that at the profit maximizing point, transport and pollution should equal its marginal cost. In this case one of the products "produced" by the shipping company is pollution which in this case has zero price, thus the profit maximizing conditions say to produce pollution until the cost of an extra unit is zero (Varian, 2006).

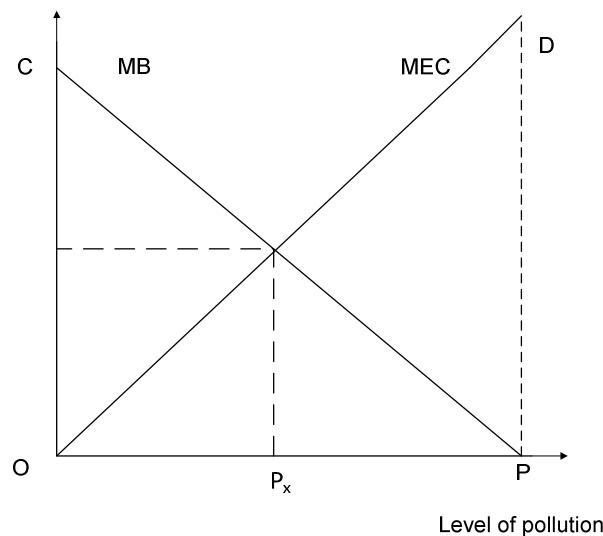
In this case it is easy to see the externality - the farmer cares about the pollution but has no control over it - and the shipping company only looks at the cheapest way of transporting goods to maximize profits without any consideration of the costs it imposes to the farmer. This means that in general the shipping firm will produce too much pollution because it ignores the impacts it has on the farmer.

2.7.2 Environmental regulations

The environmental regulations will help to achieve a balance between the objectives of the economic system and the environmental system. It is important to balance the needs of the current generation and the future generations. When it comes to air pollutants caused by the shipping industry, the major problem is to balance the costs related to health and environmental problems with the increased fuel costs encountered by the industry (Ma, s.2002). Generally, when costs rise in an industry they are paid by the consumers as the rates tends to rise when environmental regulations force companies to act. But this feature

shifts the demand and supply curve out of equilibrium as an additional cost accumulates. If prices are elastic, even a slight increase in costs can have significant effect on the supply of freight. The figure below illustrates the equilibrium relationship between marginal benefits and marginal external costs.

Figure 18: Cost of externalities



As the figure shows, the MB line (Marginal benefits) declines due to the rule of the declining rate of return, this means that as the level of pollutants rises the rate of return will decline making it relatively cheaper to reduce pollution as the marginal rate of return slides down (Ma, s.2002). The other line marked MEC (Marginal external costs) increases as the economic activity grows. The area under CPO represents the total benefits while the area under DPO represents the total external costs. The optimal level of pollution will be in point P_x . In free markets this level is not automatically achieved due to difficulties associated with property rights and increased costs related to these externalities (Ma, s.2002). This means that environmental regulations like the Marpol Annex VI have to correct the deficiencies by controlling the pollution at the optimal level.

One of the most fundamental criteria for evaluating environmental regulations is the economic efficiency between benefits and costs. The aim of the regulations is to make sure

that the positive effects are larger than the negative effects, and that the welfare effect on the society is maximized. This means that in the process of selecting the best regulative option one should try to identify, quantify, compile and evaluate all the subsequent benefits and costs in order to implement the most efficient solution.

3 Transport economics

3.1 Transport markets

As any other market the transport market is a determined interaction between the amount the market offers (supply) and the demand for the offered goods. However there are special features that are characteristic to this market. One of these is regulations either in the form of governmental or other decision makers like the IMO. The governmental regulations that affect transport can include environmental regulations, infrastructural legislations or trade barriers in the form of customs and subsidies, which will affect the flow of transported goods.

Another is the time factor which is important in transport, as transport cannot be stocked like other goods; this feature makes it difficult and resource demanding to estimate the correct supply to match demand in both short and long run.

Also, it exist quite different kinds of transportation possibilities, which differ from the goods that are transported. In shipping there are two major types of transportation modes; liner and bulk transport, with very different characteristics. The partition is marked by the type of cargo which also determines the parcel size and the type of shipping operation. In the bulk industry the main principle is one cargo one ship, with large parcel sizes transported irregularly depending on monetary demand, while liner shipping is determined by small parcel sizes that are shipped regularly between prescribed ports (Stopford 2009). The cost structure differs between these industries as bulk shipping operates at the low end of the unit cost function while liner companies and land based transport operates at the high end due to substantial costs related to ensure a good quality of service, speed and reliability (Stopford 2009). These different markets are linked together on the demand side by the possibility of substitution and on the supply side by the possibility of switching inputs e.g. ships from one market to another.

3.2 Supply & demand determinants in shipping

The shipping market consists of two key participants where the shipping companies constitute the supply side and the shipper's amounts to the demand side. Their interactions in the transport market will determine the price and quantity offered in the market based on the aggregated supply and demand. But before this point is reached there are several projecting factors that influence the participant's actions, and thus the supply and demand of transportation. On the demand side the key determinants are; the world economy, seaborne commodity trade, average haul, random shocks and transport costs, while world fleet, fleet productivity, shipbuilding production, scrapping and losses and freight revenue are the most influential factors on the supply side (Stopford 2009). These variables are interconnected by a cash flow between the four closely related under markets which together sums up to become the sea transport services. These different market places consist of; the freight market that trades in sea transport, the sale and purchase market that trades in secondhand ships, the new building market that trades new ships and the demolition markets that deal with ships for scrapping. The freight market is the main source of cash inflow, even though asset play can represent a significant part of the total revenue. The only market that only generates net cash outflows out of the shipping industry is the new building market that uses the cash to pay for materials, labor and profit (Stopford, 2009).

The interactions between these four markets drive the shipping industry through different cycles. This starts when the freight rates rise and cash is flowing into the industry, this leads to increased investments in new and secondhand ships resulting in increased prices for tonnage. The upwards spiraling cycle goes into reverse when the new ships enter the market and supply exceeds demand pushing freight rates down to marginal costs, resulting in layup or scrapping of the least productive ships (Stopford 2009).

The scope of this thesis will not include the macroeconomic variables that influence the demand and supply of transport. The reason for this is that these variables are on a global scale and cannot be influenced directly by the individual market participants. This point is especially evident when it comes to liner shipping as these services are fixed which makes it

even harder for this industry to adapt to external impacts. The variables that will be analyzed are transport costs on the demand side, and freight revenue which relates to the supply side. These two variables are strongly dependent on each other as increased transport costs tend to drive down freight revenue and vice versa.

3.3 Transport supply

In chapter 2.3.2 the general supply function of a firm in perfect competition was explained. I will now use this theory as a foundation linked to the general supply of transport, mainly emphasizing on the supply of liner transport treating other relevant transport modes as substitutes.

3.3.1 Shipping costs

The shipping industry is like any other industry dependent on several factors to obtain its aggregated supply, and like the general supply function explained in chapter 2.3.2 the supply of shipping transport is dependent on the costs the firm incur by its operations. It is necessary to be more industry specific when looking at the supply of a shipping market. Stopford (2009) divides the main cost categories of operating a fleet into five main categories:

- Operating costs, which involves the expenses needed to run the ship on a day to day basis, essentially those costs such as crew, stores, and maintenance that will be incurred whatever trade the ship is involved in.
- Periodic maintenance costs that are incurred when the ship is dry docked for major repairs.
- Voyage costs which are variable costs associated with specific with specific voyage and consist of such items as bunker fuel, port charges and canal dues.
- Capital costs which will depend on the method used to finance the ship.
- Cargo handling costs which represent costs related to loading, Stowing and discharging cargo, these costs are as mention earlier particularly important in liner trades.

The discussion concerning these five cost categories and how they affect supply will primarily be based on the consideration of four basic aspects that influences the cost structure of a vessel in the short run; these aspects are according to McConneville (1999):

1. The dimension of the vessel
2. The speed of the vessel
3. The voyage distance
4. Duration of time in port

Scale economies

The relationship between the ship size and costs are referred to as economies of scale. Because shipping is about transporting goods it is natural to define the costs per unit transported which, in the case of liner shipping, will be costs per TEU transported. The relationship between ship size and total costs can be found by adding up all the costs related to the shipping service and divide it by the numbers of TEU's or DWT it handles in a year:

$$C_t = \frac{OC_t + PM_t + VC_t + CHC_t + k_c}{TEU_t}$$

C_t = Cost per TEU per annum

OC_t = Operating costs per annum

PM_t = Periodic maintenance costs per annum

VC_t = Voyage costs per annum

CHC_t = Cargo handling cost per annum

K_c = Capital cost per annum

TEU_t = Transported amount of TEU's per annum

This relationship is important to be aware of as operating, voyage and capital costs do not increase in proportion to the transport capacity of the ship, this means that in many cases an increase in ship size can reduce unit costs, which was theoretically explained in chapter 2.4. A specific example of increased economies of scale is the 11000 TEU container ship Emma

Maersk that only requires a crew of 13, while many 3000 TEU vessels require a larger crew size to operate in an optimal way (Stopford, 2009).

Capital costs can also be reduced per TEU when investing in larger ships. While a 1200 TEU ship has a capital cost of 25000\$ per container slot a 6500 TEU vessel has a slot cost of only 13700\$ (Stopford, 2009).

Economies of scale are of great importance to the liner industry however it is important to point out that the scale economies are diminishing as the ship gets bigger. Another important factor is what the ship is intended for. If a liner company is servicing a short sea service route between small ports located close to each other, as this thesis will focus on, the ship size required would be significantly smaller than the ships used on trans Atlantic routes. Consequently this will lead to a higher transport cost per container as the benefits of scale economies would be considerably less than on the global trade routes.

Speed of the vessel

Bunker consumption is extremely sensitive to the operating speed of the vessel, increasing speed means higher consumption in general it is estimated that a 1% increase in speed leads to a 3% increase in fuel consumption, speed is therefore considered to be a variable in relation to the bunker price, as an increase in the bunker price will result in an incentive to reduce operating speed, thus keeping costs down (McConneville 1999). The reason for the emphasis on bunker costs is the fact that it constitutes as much as 39 % of the voyage costs and 21% of the total costs per voyage on a 1200 TEU vessel (Stopford, 2009). It is important to specify that these cost fractions are clearly related to bunker prices which are quite volatile; however this example demonstrates that there can be considerable cost savings/charges related to fuel expenditure. This is because the ship-owner is a price taker in the bunker market he has no control over the bunker prices but he is able to control the consumption of the vessels and consequently the bunker costs by adjusting the speed of the fleet. Perceptibly this will also influence the amount of transport supplied and hence the revenue generated by the ships. This relationship puts the ship-owner in a position where he is confronted by the tradeoff between fuel savings and revenue loss (McConneville 1999). The decision that the ship owner will take is principally dependent on two variables; bunker prices and freight rates. In a market with high freight rates it pays to steam at full speed,

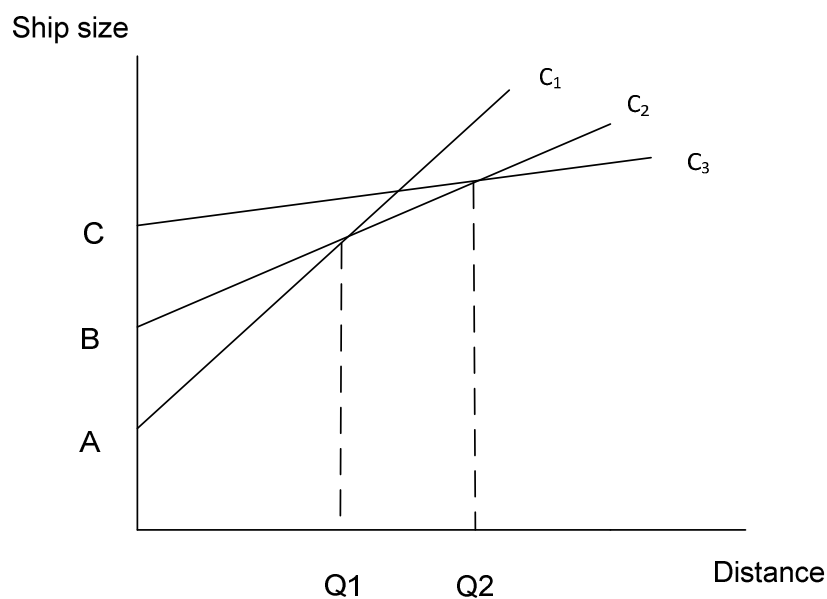
while low freight rates combined with high fuel prices will make it more economical to steam at a slower pace, because the fuel savings can make up for the loss in revenue (McConneville 1999).

Voyage distance

An increase in the transport distance with a given size and speed of the vessel will unavoidably increase the costs of fuel, and thus operating costs (McConneville 1999). A doubling in distance will generate a 18 % increase in transport costs, which means that the distance elasticity is close to 0,2 (Clark et al. 2003).

As earlier mentioned the liner industry operates with fixed services, making it hard to adjust the supply of the industry, based on a change in the distance of the routes especially in the short run, however it is important for the ship-owner to choose the optimal size of the ship used for the route in question. The relationship between ship size and distance are shown in the figure below:

Figure 19: voyage distance VS ship size



The figure shows a case with three different sized ships A, B and C. A being the smallest one. The vessels are represented with three different cost curves C_1 , C_2 and C_3 . There will be a number of fixed overhead costs at first, which are usually related to the vessels size. These costs are represented by the vertical distance between 0 and the starting points of the different cost curves. We can observe that the fixed costs rise according to the ships size, and that the distance elasticity decreases as the ships gets bigger. Q_1 Represents the distance where the total costs of running the vessels A and B are equal and point Q_2 marks the point where it will be cost efficient to increase ship size to C.

Port time

The time spent in port depends on the ships characteristics, the loading facilities and the cargo being loaded. In general the bulk ships spend less time in port relative to the ships size than container ships; this means that the bulk ship can use more time carrying cargo than the container ship, which makes it especially important to focus on efficient cargo handling systems in the liner industry, to achieve increased flexibility and cost reductions (Stopford 2009).

The size of the vessel is the most prominent factor related to the time spent in port, and will have a direct impact on the overall total costs, as the port charges usually are based on the ships dimensions (McConneville 1999). Another cost element related to the vessels size are the capital depreciation costs which also increases with port time in terms of working cargo. Both these costs can be considered as time costs. There will also be a cost element related to the alternative to waiting in port, as the ship could have been in transit generating revenue if the turnaround had been more rapid or the ship had not made the port call at all, this cost is referred to as opportunity cost of time (McConneville 1999).

In the case of liner shipping, especially in short sea trades, there will be a considerable time spent in port compared to bulk shipping. This is a part of the service quality this segment provides, however it is possible for the ship-owner of a short sea route to leave out some ports making the service more efficient, which can affect some of the flexibility of the service resulting in a loss of costumers (McConneville 1999).

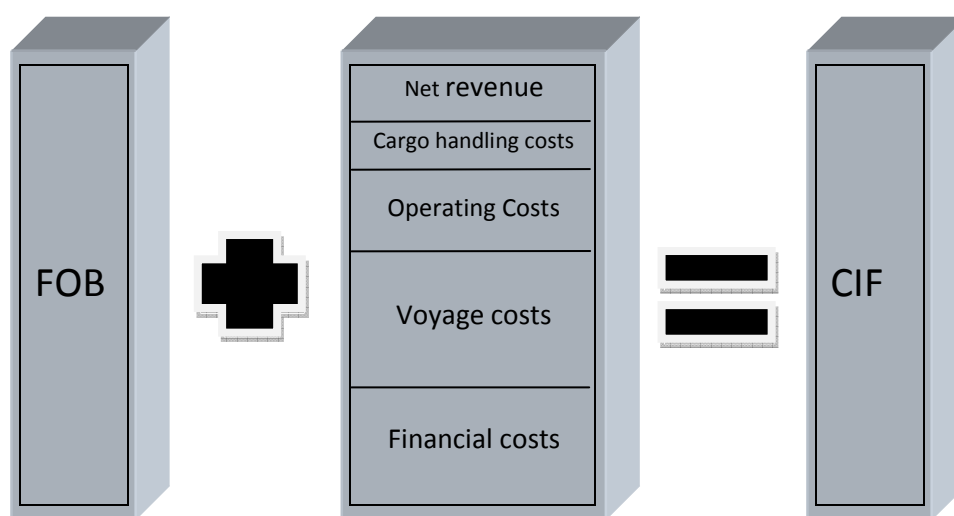
It is quite evident after looking at the different aspects of the cost structure facing shipping companies that most of the cost factors are interrelated in some way. The most prominent factor concerning the cost structure of a liner service will be the size of the ships used to provide the transport needs of the shippers, as the efficiency of the fleet will to a great extent decide the supply of liner transport on a route.

Revenue

To get an adequate picture of what level of supply the transport providers will offer, it is important to look at the revenue part of the total transport cost equation. This will also explain a part of the total transport costs that face the transport demanders. The reason for this is that transport costs are usually measured as the difference between CIF and FOB prices, and can also serve as an estimator of the transport company's revenue. The FOB (free on board) value is the price of the commodity delivered at the transport provider that will carry it, while the CIF (Cost, Insurance and Freight) value is the price of the commodity when it has been delivered to the receiver of the shipment (Wergerland and Wijnolst 1997). The cost element in the CIF value represents the FOB price, this means that the difference between CIF and FOB prices is insurance and freight, where freight generally constitutes the major part of the costs (Wergerland and Wijnolst 1997).

Francois and Wooton (2001) define the difference between FOB and CIF values as the relationship between the shipping margin, costs and revenue which can be illustrated by the model below.

Figure 20: CIF and FOB relationship



The size of the profits will depend on, to what degree the transport provider is able to enlarge his shipping margin, at the expense of the consumers and/or the producers as a result of market power. The firm's market power is strongly related to the concentration of the industry as explained in chapter 2.5.2. According to Francois and Wooton, market power is explained by the shipping firm's ability to charge freight rates that exceeds the shipping firm's marginal costs and the capability of reducing the exported quantity and price of the producers relative to what it would be in a competitive market, which is referred to as monopoly power (Pindyck and Rubinfeld 2005). This means that in a case of significant market power like in a conference situation the firm will be able to adopt pricing strategies such as price discrimination as shown in chapter 2.6.

One of the main distinctions between a perfectly competitive firm and a firm with monopoly power is, that the perfectly competitive firm will produce where price equals marginal costs, and the firm with monopoly power will be able to charge a price that exceeds marginal costs. This means that we can measure the firm's market power by examining to what extent the profit maximizing price exceeds marginal costs. This type of measure is called the

Lerner Index of Monopoly Power and can be expressed mathematically (Pindyck and Rubinfeld 2005):

$$L = \frac{P - MC}{P} = -\frac{1}{\varepsilon_d}$$

The Lerner index value will always be between 1 and 0, where a perfectly competitive firm will be $L = 0$, which means that the index will increase towards 1 as it obtains increased market power. It can also be noted that the monopoly power also is expressed by the elasticity of demand facing the firm (ε_d). Pindyck and Rubinfeld (2005) points out 3 determinants relating to a firm's elasticity of demand that can be used in the context of transport economics. The first one is; the elasticity of market demand which is important because the firm's own demand will be at least as elastic as the market demand, consequently limiting the potential for monopoly power. It is a useful tool to show the shippers sensitivity to freight rate changes that can be induced by increasing costs related to the use of distillate bunker fuel. A more inelastic demand curve associated with the firm, signifies a more competitive market structure making it harder to increase freight rates. Land based transport working as substitutes for short sea shipping may be an important driver of the price elasticity of demand, as this transport mode may drive down the shipping firms Lerner index on a specific route.

The second determinant of market power is the number of firms operating in the market, which will depend on the attractiveness of the market and on barriers of entry; the most frequent barrier to entry are scale economies (Pindyck and Rubinfeld, 2005), these factors are explained in chapter 2.5.2 and 2.4 respectively.

The third determinant is the way firms interact with each other, which refers to the competitive intensity of the shipping market. The market power of the firm will depend on whether firms operating in the incumbent market cooperate or are in fierce competition (Pindyck and Rubinfeld, 2005). As mentioned in chapter 2.5 the strategic history associated with liner shipping is cooperation of some sort, consequently increasing the firm's market power and mark up price.

Market power is strongly connected with market structure, and it has been pointed out that the shipping industry is associated with few competitors and monopolistic behavior, however it can exist a considerable threat related to potential market entrants, being either in the form of other transport modes or liner companies.

3.4 Transport demand

According to Cole (2005) the most important factors explaining the demand for transport services will be:

- The physical characteristics of the product transported.
- The price of the service
- The relative price of substitute transportation modes
- Costumer income
- Quality of service

Some of these variables are mainly concerned with passenger transport, but can be applied to transportation of general cargo, especially in the liner service where the quality expectations are higher than in the tramp service.

The quality of service variable will include three sub categories, which according to Stopford (2009) are characterized as; speed, reliability and security and adds up to underline the customers opinion of the service. In addition to these three elements he also points out price in the case of product differentiation.

If we look at transportation from the viewpoint of a firm that produces goods, the transportation costs will be considered as a factor input on the same line as any other costs, and can be explained based on the theory of factor markets. This theory explains that the factor demands are derived demands, which are dependent on the firm's level of output and costs of inputs (Pindyck and Rubinfeld, 2005). This means that the costs related to the firms inputs will correspond with the price of the service as explained in chapter 2.3.2, and that the supply of the firm will depend on the consumer's demand for the end product.

Price of service & physical characteristics

It is natural to connect the price of the transport service and the characteristics of the shipped good; the reason for this is explained by the difference in the way the various commodities are affected by freight changes. Freight rate changes will affect the shipper's demand for transport in two ways. First it will affect the costs faced by the shipper connected to the transportation of the goods, as mentioned in chapter 3.2 the key variable in the shipper's demand function will be represented by the freight rate, because the shipper measures the output achieved by using transportation as an input factor against its product price. Secondly freight rate changes can alter the delivered price of the commodity transported and its relative prices.

To measure the sensitivity of demand to price, we can use the price elasticity of demand measure that was introduced in chapter 2.3.1, this elasticity generally depends on the availability of other goods that can be substituted for it. In the case of short sea liner shipping the substitutes like road transports, can cause a demand shift towards roads in the case of a freight rate increase induced by the shipping industry. The elasticity of demand changes according to the industry (Pindyck and Rubinfeld 2005); it is therefore natural to assume that elasticity of demand changes between different transport modes as well. This can lead to some difficulties connected to the measurement of the aggregated elasticity of demand from an industry, the time and differentiation factors adds to the measurement problem as it takes time for the consumers to adjust to the changed price and the fact that transport services can differ in the way they are performed (Cole. S, 2005).

As pointed out at the beginning of the chapter, transport costs affects shippers demand in addition to the isolated cost element related to transport, this can lead to indirectly altering the transport demand and modal choice as a result of a change in the delivered (CIF) price of the goods and their relative prices. According to Hummels (2007) a value-to-weight ratio can be a useful estimate of the impact that transport costs will have on the delivered price and on the relative price compared to other products. Hummels (2007) uses an example that includes two equal goods (wristwatches) with different values, one costing 10\$ and the other one costing 1000\$. Both goods need to be transported the same distance between A

and B. Based on this example I will explain the logic behind the value-to weight ratio and to illustrate the effects of transport costs on two goods with different price characteristics. The numbers are chosen randomly and will not reflect real prices.

If we assume that the high value goods require a higher quality of service such as more insurance, greater care in handling and quicker delivery, the cost of transport will presumably be higher per unit transported, but not 100 times more expensive than the low value good, consequently making the low value good relatively more expensive compared to the high value good. This can be shown in the table below:

Table 2: Low value VS high value Goods

	Low value Good	High value good	Relative Prices
FOB cost	10	1000	$10/1000=1\%$
+ Transport cost	2	4	
= Deliverd price (CIF)	12	1004	$12/1004=1,2\%$
Transport costs/CIF	16,70 %	0,40 %	

The table above shows the relationship between high and low value goods as well as the transport cost's share of the commodity price. We can isolate this relationship by having two goods at equal value-to-weight ratio that requires different quality of service. This relationship is shown in the table below, where transport costs amount to 5% of the commodity price for goods 1 and 20% for goods 2.

Tabell 3: Different transport quality

	Goods 1	Goods 2	Relative Prices
FOB cost	100	100	$100/100=1$
+ Transport cost	5	20	
= Deliverd price (CIF)	105	120	87,50 %
Transport costs/CIF	4,80 %	16,70 %	

The conclusion that can be taken following the examples above are, that high value-to-weight goods will be less affected by an increase in transportation costs and that low value goods will be relatively more expensive compared to high value goods in case of a increase in transport costs.

Costumer income

I mentioned in the introduction of this chapter that the demand for transport as an input factor will depend on the output level of the firm and transport costs. The costs of transport will be discussed in the next section while this section will focus on the firm's output level. As pointed out in the introductory part of this thesis transport services are driven by the demand for final goods. There are several factors that drive this demand, one of which is the income of the end consumer. This relationship is explained by the income elasticity of demand explained in chapter 2.3.1.

In addition to the effect a change in income has on the demand for a product, Hummels (2007) mentions that a rise in consumer income can have an effect on explaining time sensitivity on commodities. Cole (2005) also mentions in the context of passenger transport that as income increases the customers become more demanding. I assume that this will be the case for the quality of transport in general as well, which means that the sophistication of the transport services will raise as consumer income increases.

Price & speed of substitute goods

The major competition facing the shipping industry is truck, railroad and air transport. Depending on the length of the haul, land based transport is best suited for shorter transport distances, while air freight works as a substitute on the longer hauls especially, with high value commodities. It is not specified that land based transport is the perfect substitute to Short Sea Shipping even if they possess the same quality characteristics, the reason for this is that some modes of transport are not suited for all types of freight, indicating that the degree of substitution is determined by the type of cargo it transports. As this thesis focuses on the effects with reference to Short Sea Liner Shipping it will be most appropriate to consider road transport as the most significant competition facing the Short

Sea Liner Shipping industry in Northern Europe. I will thus consider road haulage as the only substitute in the context of this chapter.

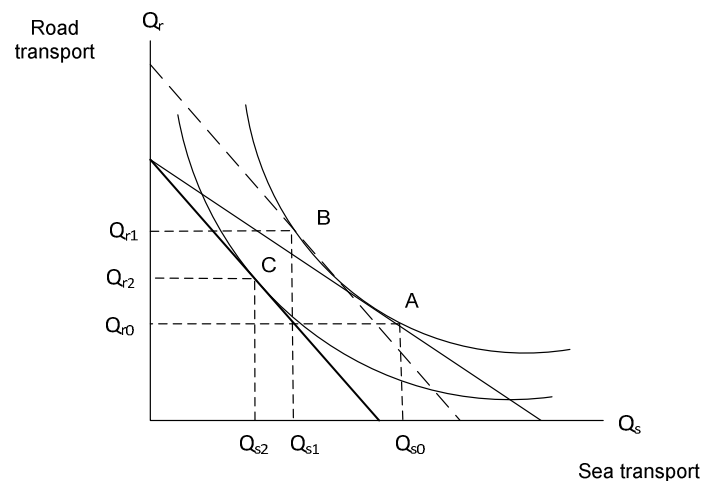
Since it is assumed that the cargo allows for different transport modes, the degree of substitution will depend on the cross price elasticity of demand, which is mathematically defined in the following way (Pindyck and Rubinfeld, 2005):

$$\varepsilon_{Q_r P_s} = \frac{\Delta Q_r / Q_r}{\Delta P_s / P_s} = \frac{P_s}{Q_r} \frac{\Delta Q_r}{\Delta P_s}$$

Where Q_r is the quantity transported by road and P_s is the price of sea transport. The cross-price elasticity of demand between these two transport modes tells us how much the quantity demanded for road transport will change as a result of a 1-percent increase in the price of sea transport. Because we are referring to substitute goods the cross price elasticity will be positive, and as a result of the competition a rise in the price of sea transport will make road transport relatively cheaper, thus increasing the demand for road haulage (Pindyck and Rubinfeld, 2005).

This relationship including the income effect caused by a cost change in transportation is illustrated graphically in the figure below:

Figur 21: Income & substitution effects



Looking at the graph we can observe that the consumer is originally at point A but as the costs of transport increases he substitutes sea transport for road transport as this is now relatively cheaper. This is called the substitution effect and implies that sea transport will have a negative substitution effect representing the difference between Q_{s0} and Q_{s1} ; hence road transport will experience a positive substitution effect representing the difference between Q_{r0} and Q_{r1} . In addition to the substitution effect the market participants will experience an income effect, which in this example is negative due to the fact that the goods are normal, thus making the two firms adopt in point C.

It is important to emphasize that the income and quantity relationship shown in the graph above are merely theoretical with randomly chosen conditions, which do not necessarily reflect real circumstances.

A factor that will be somewhat important in the transport service is the time factor which in many cases represents the main differentiation factor between different transport modes. There is usually a premium related to the time aspect caused by the fact that time is considered as valuable for many shippers especially in the case of “just in time” distribution (Hummels 2001). Generally shipping is considered as a relatively slow transport mode with corresponding freight rates, this is the case in the longer hauls in competition with air freight. In the case of Short Sea Liner shipping there will not be considerable differences in the time of transport; however there can be time savings associated with roads transport in the case of door-to-door transport. This is especially relevant in the shorter hauls when the shipping company only takes the responsibility for the ocean leg and the cargo has to be loaded on to another transport mode to reach the final destination, this can result in a time advantage for road haulage as the time related to loading, unloading, transshipping and setting up cargos can be reduced. In these cases the shipper can be willing to pay a premium for faster transport, which is referred to as price/speed trade-off, and will depend on the shipper’s time-costs and time sensitivity (Hummels 2001).

The door-to-door service mentioned above often requires several transportation modes especially if the goods are shipped by sea. This means that there are often numerous operators involved in intermodal transportation (Ludvigsen 1999). In the cases when the

ocean leg is considered as the core service because it covers the major part of the distance involved in the door-to-door service, road transport can be considered as complementary goods. This means that an increase in the price of sea transport will lead to a reduction in the need for the corresponding road transport needed for door-to-door services (Pindyck and Rubinfeld 2005).

Quality of service

As mentioned in the introduction to this chapter Stopford (2009) defines quality of service as price, speed, reliability and security as quality parameters. I will not include price as a quality parameter in this context. There are two reasons for this; the first being that price as a influence of transport demand is already explained above, secondly I do not regard price to be a quality of its own, because the price on a service is often justified by the other quality measures, making it hard to validate the price without knowing something about the other service qualities.

Speed of the transport service is an important quality feature of the transport service, according to Hummels (2001) the reason for this is that shippers face two different costs related to the general cost perspective of transportation; firstly the monetary cost which is the equivalent to the freight rate, and secondly the indirect time costs which is related to the time the commodity spends in transit. The time cost aspect consists of two different factors that accumulates to the overall time costs; inventory holding costs and depreciation costs. The importance of time costs is related to the interest rate and the characteristics of the commodity in question; this is because the commodities value will depreciate as time goes. Some goods are more sensitive to time costs than others examples of this are high tech electronics and food. In addition to this will there be a cost of uncertainty related to the time spent in transit which adds to the risk of transportation.

Depreciation costs are generated by the commodities value loss over the transit time, while the inventory holding costs reflects the goods in transit, and the buffer-stock needed at final destination to accommodate variations in transport time. The cost of time is probably more relevant in the case of longer hauls as the transport time is a considerable factor in these

trades, while the short sea shipping routes generally have much shorter transit time; however the importance can be apparent in case of highly time sensitive commodities.

The time sensitivity of the shipper is related to the time costs and expresses the importance of transit time for the shipper. In the case of high time sensitivity the shipper incurs substantial time costs related to the transit time of the commodity and vice versa. Hummels (2001) argue that US shippers are willing to pay a time premium of 0,8 % per day saved in the case of manufactured goods on a 20 day transport leg. I will assume that this number will be smaller as transport time decreases. Nevertheless time is an important aspect of the quality associated with the transport service, consequently affecting the demand for different transport modes in accordance with the time sensitivity faced by the shippers.

Frequency can also be included as a quality parameter and is closely related to the speed of the service. In Ludvigsen's (1999) research she mentions that frequency can be regarded as one of the service quality proportions under the category regarding operational excellence. The cost accrued in addition to the monetary cost of transport and time costs imposed by transit time, is the cost that is related to the frequency of the service and is called hidden waiting cost (Hummels 2001). While time costs refers to the time in transit, hidden waiting time is directly related to the waiting imposed by the frequency of the service as well as the differences between shippers preference related to the timetables and actual frequency of the service. This means that the shipper will set requirements to the speed and frequency of the service in order to minimize costs, which means that the frequency of the service is important to the demand side of a transport service, as a difference in speed and frequency between competitors or transport modes, can lead to a demand shift to the transport provider who supplies the most frequent service.

Reliability represents another quality measure, and refers to the ability the transport provider has to deliver the transported goods in accordance with what has been agreed (Stopford 1997). Reliability is particularly important for the shippers who use "just in time" stock control systems, which will make these shippers more time sensitive than others; thus having higher willingness to pay for this characteristic.

Security is related to the reliability measure, because loss and damage to the transported goods in transit will undoubtedly cause problems for time sensitive shippers. Shippers who transport fragile and high value commodities will probably be prepared to pay more for secure transportation to make sure that their parcels are secure and arrive on time (Stopford 2009).

All of the factors presented in this chapter will together add up to the aggregated demand of a transport service. The aggregated demand will as noted above rely on the consumers preferences and in which way the shipper emphasizes his transport needs, and on the commodity transported.

3.5 Pricing transport services

The price of a transport service is derived from the market clearing of supply and demand in the market. The market consists of transport providers on one side who supply transport in accordance with the cost level they are faced with, and shippers who act in accordance with the demand parameters on the other side.

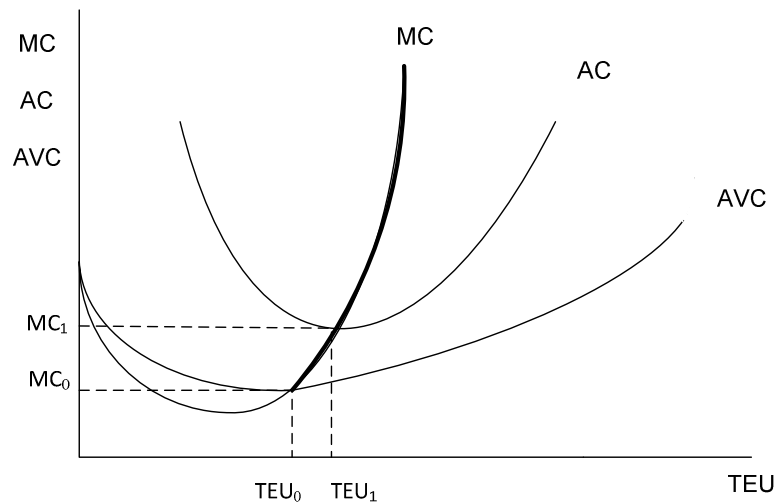
3.5.1 Liner service pricing

To get an adequate picture of the transport supply, I will first show the transport supply curve derived from a single containership, as well as the different pricing methods this ship-owner can use to affect revenue and thus the price of transport.

The figure below follows the same logic as figure 11 that was introduced in chapter 2.3.2 concerning supply in a competitive market. Even if the market is not perfectly competitive in practice, this example assumes that in the case of a rationale ship-owner, no transportation will be supplied at a price lower than MC_0 , as the firm will lose money by entering/proceeding the business at that price level. The shipper will only produce at this level in the long run if the fixed costs are considered as sunk costs (Varian 2006). In the case of a liner shipping company; sunk cost can consist of cargo handling terminals or other investments made to establish a transport service; however if the fixed costs are accrued

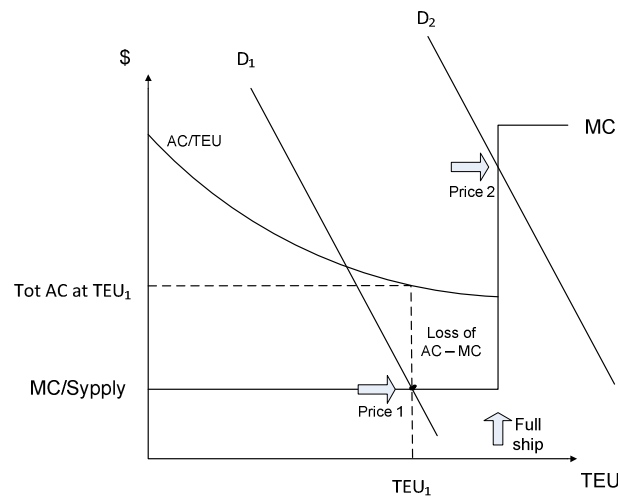
frequently to keep the service going, the liner company will need a price level of MC_1 to supply the service. As in figure 11 the supply will still be given by the marginal cost curve.

Figur 22: Liner service costs



As noted before the liner company has to generate enough revenue to cover all its costs, if this is not achieved the ship-owner will go out of business. Even if some of the fixed costs are characterized as sunk cost, the liner company will always have frequently incurred fixed costs related to the operation of the fixed service the company is committed to running regardless of the cargo volume (Stopford 2009). The supply-demand graph below shows a simplification of the marginal cost pricing strategy a liner company can succeed to maximize revenue in order to cover the average costs.

Figur 23: Marginal cost pricing



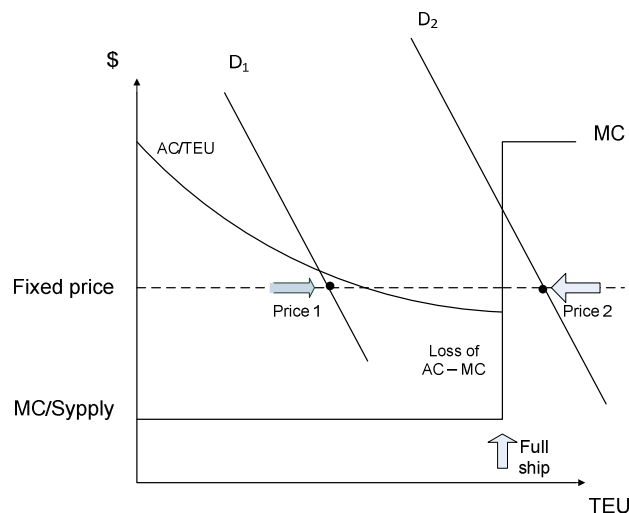
Source: Stopford, M (2009) *Maritime Economics 3rd Ed.*
 London: Routledge p.552

The graph above shows what happens in a free market without conferences and cartels. There are two different demand scenarios D_1 and D_2 which represents low and high demand respectively for this transport service. At the low demand level the shipper will bid against other shippers for available cargo. This bidding will proceed until the offered price equals the marginal costs at price 1 and the shipped quantity of TEU_1 . At this level the ship-owner will lose the margin between AC and MC which will depend in the size of the fixed costs related to the running of the operation. The marginal cost curve which also represents the supply curve of this particular ship is perfectly elastic from the first container slot to the point where the ship is full and the supply curves shifts to be completely inelastic, at this point the negotiation power lies in the ship-owners hands and the shippers starts to bid up the freight rates until the price of shipping one TEU reaches the level where the costs of hiring slots or chartering another vessel equals the price on the initial ship.

The shipping market is a very volatile market and it is important for the shipping company to make enough profits during the good years to survive by subsidizing the operations during the bad years (Stopford 2009).

An alternative pricing strategy is to fix the freight rates at a level that will provide a reasonable margin over average costs. This strategy is explained by the graph below.

Figure 24: Fixed pricing



Source: Stopford, M (2009) *Maritime Economics 3rd Ed.*
London: Routledge p.552

The supply and demand curves are the same as before, however we can see that the price is fixed, which in the case of low demand leads to a total revenue just below average costs as the ship is only half full. In the case of high demand the total revenue will exceed the average costs as the demand is higher than the capacity of the ship.

If this pricing policy is maintained in a strict manner, the ship-owner will experience a stable cash flow, as the company incurs smaller losses in a recession and thus smaller profits during a boom (Stopford 2009). Compared to the marginal cost pricing case in a free market the cash flow cycles are reduced, as well as the customers having the advantage of more stable prices (Stopford 2009).

There are problems related to this pricing strategy, one of them is the problem of free entry to trade, which results in a situation where the ship-owner will not make any excess profits because of new firms entering, and existing competitors expands capacity when a boom occurs. If these market participants do not follow the fixed pricing strategy set up by the cartel, they will soak up the premium cargo at profitable prices (Stopford 2009). Another problem associated with fixed pricing strategies, is the tremendous incentive firms have to

break out of the conference and lower their prices, filling up their vessels during a recession as the fixed prices are way above marginal costs (Stopford 2009).

Another price strategy is price discrimination; and is theoretically explained in chapter 2.6. This type of pricing combines the fixed cost pricing with the marginal cost pricing in order to increase revenue.

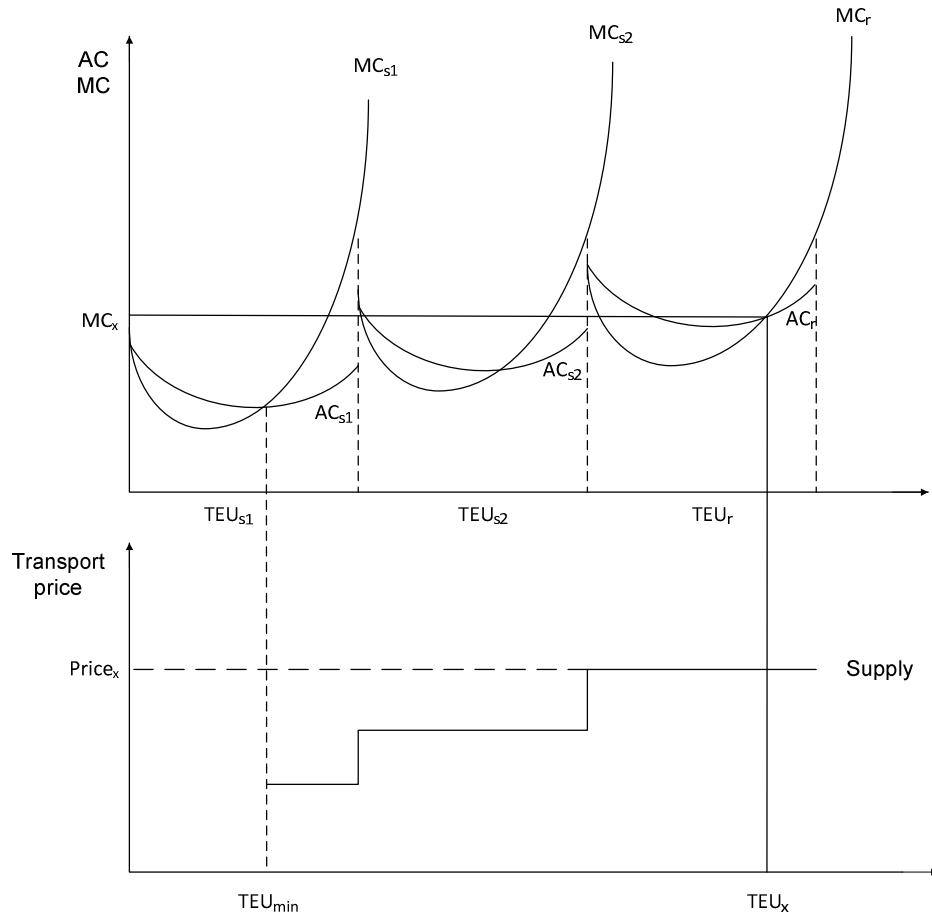
This pricing strategy is especially relevant in times when the demand for transport is low and the ship has room to spare for additional cargo. In these cases the liner company can offer freight rates at a discount to shippers with low value cargo in order to fill up the ship. As long as the discounted price covers the costs related to the cargo handling, the liner company will increase its revenue. Price discrimination is a widely used strategy in the shipping business, however, it has been harder to discriminate due to the standardization of the physical cargo in the form of containers (Stopford 2009).

3.5.2 Aggregated transport supply

To get a satisfactory picture of the aggregated supply on a transport route, substitute transport modes have to be included in this supply and demand study. As noted before, the cost structure of the substitutes will not be thoroughly examined, as the focus of this thesis deals with the cost effects relating to the shipping industry.

It will be necessary to make some assumptions in order to demonstrate the aggregated supply of transport in a graph. The graph below deals with one transport route, where there exist two shipping companies with slightly different cost structures, and one road transport provider. This graph will give a simplified picture of how the aggregated transport supply on a specific route will look in these circumstances.

Figure 25: Aggregated transport supply



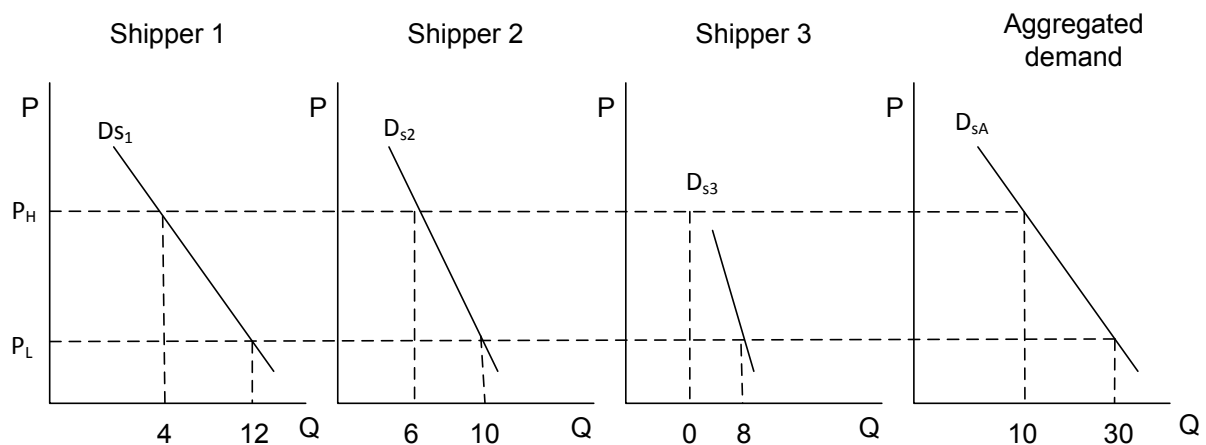
This example shows that shipping company 1 has the lowest cost structure characterized by the lowest marginal costs in the graph above. This means that this is the first transport provider to enter this market, and consequently the transport supply will start at TEU_{min} where $MC_{s1} > AC_{s1}$. As the price rise it will be profitable for shipping company two to enter the market, at this point the transport supply will include TEU_1 and TEU_2 making the supply curve suddenly rise to a new level in a stair shape as shipping company 2 enters the market. In this example it is the road transport that holds the highest costs. Which means that at MC_1 road transport will be supplied on this hypothetical route at $price_x$ and the total transport supply will be TEU_x .

It is important to point out that this is merely an example of how the substitute transport modes may interact on a particular route under these cost structures, and to obtain a picture of how the aggregated transport supply is derived in the case of several transport providers.

3.5.3 Aggregated transport demand

The demand curve for aggregated transport is assumed to follow the same reasoning as it did for one ship in figure 25 above. This means that all the shippers demand functions will be added together to get the aggregated demand function.

Figure 26: Aggregated demand



This figure shows that the demand curves are relatively inelastic, the reason for this is that in many cases the shippers has to transport there commodities in order to sell them to a customer at the final destination, this means that generally the shippers will be willing to pay for transport even in cases of high transport cost. The willingness to pay for transport is ultimately decided by the end consumer of the product, as transport costs will affect the total cost of the commodity. This means that goods with a high price elasticity of demand will be more affected by the changes in transport costs than others. This is shown in the figure above where shipper 3 do not find it economical to transport the product at the price P_H and the other shippers transport less which leads to a reduced aggregated transport demand.

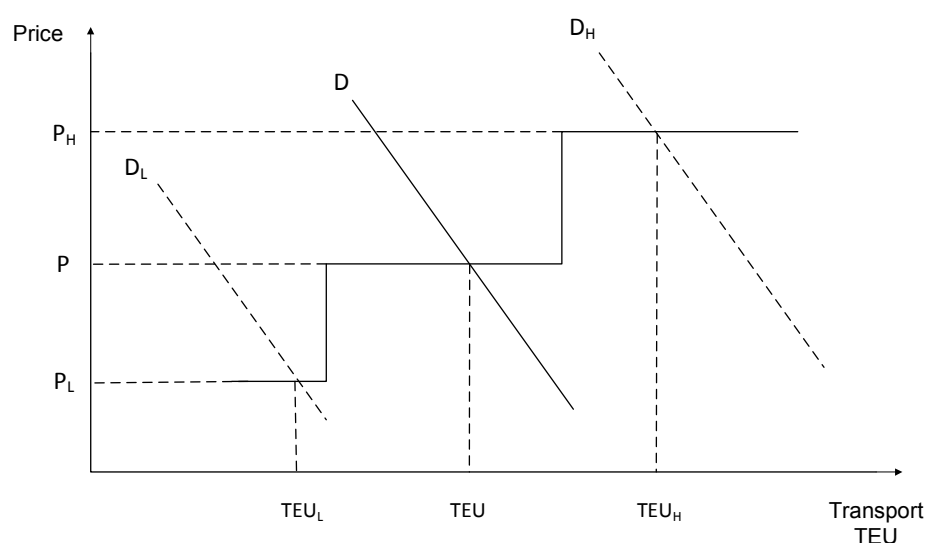
In the long run high transport costs can lead to a shift in international trade as the gains from trade explained in chapter 2.2.1 will diminish as a result of increasing transport costs. This can lead to a geographical move in the production facilities in order to reduce transport costs. This can also be relevant in the case of low transport cost where it can be economical to move production abroad due to lower production costs in order to transport them back to the home country.

It is important to point out that these shifts do not happened over night but are decisions that are taken in the long run and will also rely on other parameters than transport costs. Nevertheless it is important to point out that the costs of transport can have indirect effects in addition to the obvious transport demand shifts shown in figure 26.

3.5.4 Clearing of aggregated transport supply and demand

The aggregated demand for transport will change over time according to the macroeconomic conditions as well as the industry specific conditions explained in chapter 3.4. This leads to different levels of demand which in order has an effect on the price and transport supplied.

Figure 27: Clearing of aggregated transport supply and demand



The figure above shows how the market clears in with different transport demands. With a low demand (D_L) the supplied quantity will be TEU_L at price P_L as the demand increases the supply will increase according to the explanation given in chapter 3.5.2 thus increasing the price to P_H and the supplied quantity to TEU_H at the highest transport demand. At this price all the transport providers will be supplying transport on this hypothetical route.

4 Market effects & reactions

This part of the thesis will combine theoretical trade theory, microeconomics and transport economics in an attempt to analyze if north European Short Sea Shipping will be affected by a demand distortion caused by increasing costs due to the revised MARPOL Annex VI regulations.

4.1 Sulphur reduction alternatives and costs

Residual fuel has provided the shipping industry with low cost fuel in over 50 years, according to DNV the basic quality of residual fuel has been remarkably stable over this time period (DNV 2009). This means that the controlling parameters for refiners or blenders have only included viscosity and density of the fuel. The refiner's objective has always been to maximize the use of residues, while minimizing the production of it. In the latter years the focus on fuel quality has increased and in many regions the sulphur content of the bunker fuel has become a blend target. The reason for this is the IMO increased focus on the problems regarding the shipping industry's sulphur emissions, and the external costs these emissions cause.

These environmental regulations will undoubtedly cause increased costs for the industry, both for the refiners and the ship-owners as well as the transport demanders. The cost implications relating to the ship-owners are listed below:

- Bunker cost increase
- Capital investments related to sulphur abatement systems (Scrubbers)
- Investment in emission monitoring systems
- Loss of competitiveness to other transport modes
- Penalties/fines
- Additional administration costs
- Availability of suitable fuels
- Loss of operational flexibility

Some of these cost implications are indirect and/or substitute each other, which means that the author will mainly focus on the most prominent direct costs, which will include bunker cost increase and capital investments in order to reduce emissions (scrubbers).

The refining industry will also face additional cost due to an increasing demand in distillate fuels after 2015. These costs involve:

- Capital investments to produce additional distillate fuels
- Additional tank separation
- Unit cost increase as a result of a more advanced refining process
- Increased greenhouse emissions to handle
- Residual fuel disposal

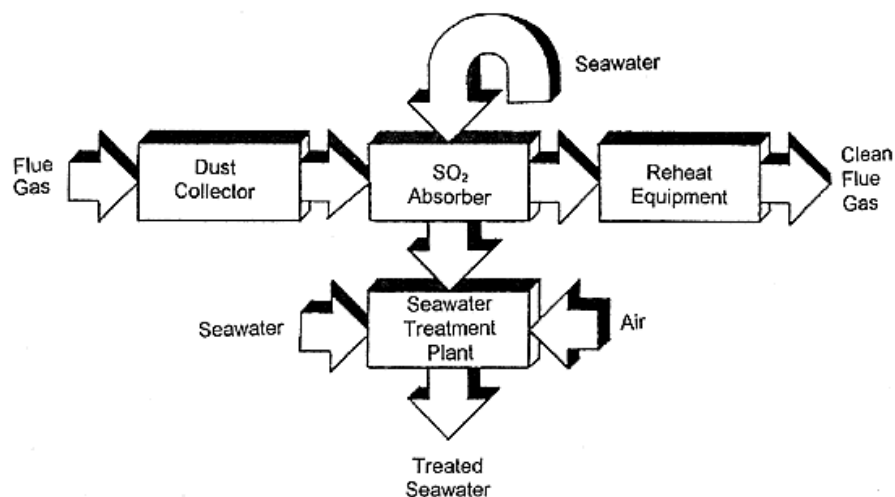
Ultimately these costs will be charged to the ship-owner in the form of increasing bunker prices, if he does not invest in some sort of scrubbing technology. In addition to this, it is also possible to convert the ship to run on gas, but this solution seems too expensive and impractical at the moment. This means that this thesis will focus on the two sulphur reducing actions being; scrubbing technology and a switch from the bunkers used in ECA's today, which is mainly LS 180/380 with a maximum sulphur content of 1,5% to distillate fuels like MDO (marine diesel oil) or MGO (marine gas oil), which are the only bunker alternatives which meet the strict sulphur emission standards in the ECA areas after Jan. 2015.

4.1.1 Sulphur abatement technology

The main sulphur abatement technology available for the shipping industry today is sulphur scrubbers. This is a pollution control technology, and the most common developed for shipping is sea water scrubbing. As this thesis focuses on the economical consequences of the regulations the author choose not to explain the technical dimensions of this technology in detail; however, I will give an outline of how it works to help the reader understand the complexity and dimension of a scrubbing installation on a ship.

Very simplified this technology can be explained in the following way; the exhaust gas stream from the ships engine is lead into contact with the scrubbing liquid (sea water) by forcing it through a pool of water, and by doing this the sulphur is absorbed from the exhaust gas. The reason for this is the alkaline salts found in seawater which are capable of neutralizing the sulphur content in the exhaust. After this process, the water is returned to the sea as drain water (Global Environment Centre Foundation). This process is shown in the figure below.

Figure 28: Seawater scrubbing



Source: Global Environment Centre Foundation

Even if this process seems fairly simple, it is a complex and expensive investment, which in addition to the direct capital costs of installing, also requires added maintenance which induces additional operating costs. Scrubbing systems also requires additional energy to run which will impact voyage costs adversely.

The scrubbing technology is a relatively new invention for the use in ships as, sulphur emissions from the shipping industry have not been of great concern until the last decade. This means that the financial implications as well as the reliability of these systems are not

fully known to the industry, but scrubbers have its supporters as well as critics. In the industry the positive arguments concerning scrubbers are:

- 90 - 100% removal of sulphur in addition to 80% removal of PM (particulate matters) from residual fuels.
- 5 – 15% removal of NOx is achievable.
- Assumed to have 25 year life-cycle which is substantial but will add difficulties to scrapping decisions.
- Takes the pressure of distillate fuel demand
- Increased second-hand value and higher charter rates

According to Krystallon (2009) one of the leading seawater scrubbing manufacturers, the economies of fitting a scrubber into a new ship will provide the best low cost alternative, as the differentials between HSFO (high sulphur fuel oil) and distillates averaged approximately \$350/tn, in 2007 and 2008. For a retrofit, the cost benefits seem less attractive and will rely on parameters like future legislations, as the use of distillates may not fulfill future emission regulations concerning PM and NOx, making scrubbing necessary and, of course, the future predictions concerning differentials on HSFO and distillates. The author is aware that this is biased information, but there seems to be numerous market participants backing up the scrubbing industry's statements concerning the attractiveness of fitting sulphur abatement technology to ships.

The arguments against scrubbers are mainly concerning:

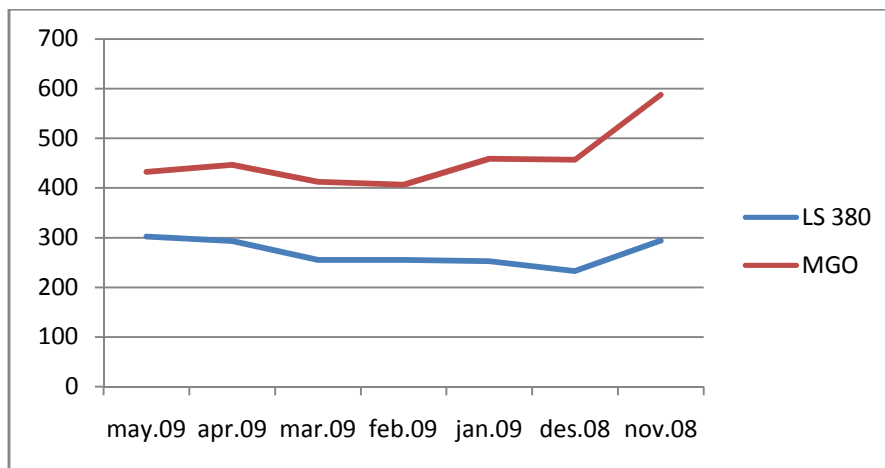
- Technical feasibility – at least six different systems under development
- Technical reliability
- Continuous emission measurements - Reliability problems can lead to fines
- Sludge disposal from PM waste
- Large space requirements
- High power requirements
- More than one needed for most ships (due to several engines)

As mentioned above, there is little doubt that exhaust gas cleaning will be a feasible alternative to the use of distillate fuels, but there are outstanding issues relating to the use and financial aspects of the sulphur abatement technology.

4.1.2 Cost & availability of distillate fuels

As earlier noted, a switch to distillate fuels (MDO/MGO) is the only option besides sulphur abatement technology for the ship-owners operating in the ECA areas after January 2015. The reason for this is that it is the only way to meet the 0,1 % sulphur cap set by the IMO. This will undoubtedly cause significant increase in the fuel costs faced by the ship-owner. There is some divergence in the industry about how large the differentials from today's levels will be, but most of the estimates range between a 50 - 100% increase in fuel costs compared to the use of regular LSRFO (Low Sulphur Residual Fuel Oil). The figure below shows the price differentials between MGO and LS 380 from November 2008 until May 2009.

Figure 29: Price\$/mt MGO VS. LS 380



Source: bunkerworld.com

As the figure above shows, the price spread differs significantly from month to month even if we can see a correlation in the price development. The lowest price differential is found in May 2009 with 43% while the largest price differential is in November 2008 and amounts to

100%, whereas the average spread in the prices is 71%. This diagram shows how the prices on bunker fuel fluctuate, and that the price differential has been reduced the last 6 months, however, the price differentials will almost certainly rise again as the supply/demand distortions in the bunker market, as well as in the world economy, normalize.

Because of the volatility of the bunker prices and unforeseen psychical shocks, the price differential between MDO/MGO and LSHFO will be hard to forecast, nevertheless it is quite safe to predict that the distillate fuel oil premium will rise after Jan. 2015 as a result of increased demand for “clean fuels. This proposition can be based upon fundamental supply demand theory explained in chapter 2.

Because of the increased demand for distillate fuels from the shipping industry, and in order to meet the terms of the ECA 0,1 % sulphur cap in 2015, as well as the additional worldwide sulphur cap of 0,5 % in 2020, Intertanko (2007) predicted that the refining industry faced investments in the range between 38bn\$ and 100bn\$ to meet the estimated additional distillate demand of 200mtpa. In the worst case scenario, the additional 100bn\$ investment will increase the distillate premium by 50\$/mt over a 10 year period.

It has to be pointed out that these predictions are made to illustrate the total refining investment costs of the whole world changing to distillates within 2020, which is not necessarily the case. However, the reason for mentioning this, is to illustrate that there will be considerable additional investment costs associated with the increased demand faced by the refining industry in the years to come, which most probably will lead to an increased premium connected to distillate fuels.

As with sulphur abatement technologies, a switch from residual fuels to distillate fuels in order to meet Annex VI environmental demands, has positive and negative sides compared to exhaust gas scrubbers. The positive are listed below (Intertanko 2009):

- Immediately reduces SOx emissions with 80 – 90%, NOx emissions with 10 – 15% and PM emissions with 90%.
- Reduces fuel consumption by 4%
- Facilitates additional NOx reductions by in engine modifications in case of stricter NOx regulations
- No need to retrofit additional bunker storage capacity
- Eliminates current onboard fuel treatment plants – additional cargo volume
- Reduces onboard engine room generated waste
- Potential spills considerably less harmful

The negative effects of switching to distillate fuels are few but considerable and concerns costs as well as availability.

The availability of distillate fuels in the future has been a concern for many of the industries participants after the revision of Annex VI. In an article published in sustainableshopping.com (02.2007) Martin Suenson executive officer of EUROPIA (European Petroleum Industry Association) expressed concerns about the refineries ability to supply the shipping industries future demand for distillate fuels, as this would call for large scale changes in the refining industry and would consequently take at least 20 years to implement. The reason for this is that in Europe alone the demand for distillate fuels will rise by about 50mt as a consequence of Annex VI, and as Europe already imports about 33mt of distillates annually, the possibility of increasing imports will be limited, given the possible global increase in distillate demand after 2020 (sustainableshopping.com 02.2007). In addition to this there will be an adverse environmental effect which will generate yearly additional 35mt carbon dioxide (CO₂) emissions from European refineries due to the energy intensives of distilling the additional “clean fuel” supply.

The concerns relating to the availability of distillate fuels in the future are warranted, because of the vast investments required to supply the amounts of distillate fuels in the future; however the IMO has taken some precautions if there should arise issues concerning

distillate supply. These issues are governed by regulation 18 in MARPOL Annex VI. The most important issues concerning fuel availability are listed below (imo.org, 10.2008):

- Each party shall take all responsible measures to promote the availability of fuel oils that comply with Annex VI.
- If a ship is not compliant, it should present evidence that it attempted to buy the compliant fuel in accordance with the voyage plan.
- The ship is not required to deviate from the voyage and should not be delayed
- If evidence is presented by the ship, showing that all possible measures to require the right fuel are taken, there should be no measures against the ship.
- The ship will have to notify its Administration and the appropriate port of call each time it cannot find the compliant fuel.

As regulation 18 states, there will be no measures taken against the ship-owner in the case of supply shortages as long as he has attempted to acquire the right fuel; however in the case of such severe supply shortages, the price of distillates will increase dramatically, and thus adversely affecting the ships voyage costs even more.

4.2 Assumptions & Freight rate increase

As mention in chapter 4.1.1 concerning the costs of sulphur abatement technology, there are considerable issues relating to the costs, availability and reliability concerning these types of sulphur reducing measures. Because of these uncertainties I will choose to use the cost estimates relating to the switch toward distillate fuels from today's low sulphur residual fuels, when analyzing the effects of Annex VI.

Because the data material available concerning the different costs related to operating a short sea liner service in a specific route inside the ECA areas is limited, I will have to use general data collected from different textbooks and rapports relating to transport costs, in order to analyze the effect an increase in bunker costs will have on the freight rates.

The general cost data will be based on the cost of operating a 1200 TEU vessel, collected from Stopford 09. The size of this vessel is in general somewhat larger than the traditional short sea vessel. There are also issues relating to the distance of a round voyage, used to calculate the cost parameters in Stopford (2009). These costs are based on a 14000 mile transpacific round voyage between seven ports while a typical short sea service route will consist of much shorter distances of as little as 50 – 1500 miles, this means that the relationship between relative time in port and relative time at sea will be somewhat misleading; however because of the scale economies explained in chapter 2.4 which the larger 1200 TEU vessel achieves compared to a smaller 150 – 700 TEU short sea vessels, the differences in the cost proportions will probably not be radically different. This is because the scale economies the 1200 TEU vessel achieves compared to the smaller vessel will, to some extent, cancel out the effects of disproportional bunker consumptions which arise due to the differences in relative port time compared to the relative time at sea. The reason for this is because a smaller ship in general consumes more bunker fuel per TEU (Stopford 2009).

The cost estimates used in Stopford 2009 are based on a utilization rate one way of 40% and 90% the other way. These utilization rates will not have much effect on bunker consumption; however, there will be some effect concerning cargo handling costs, if the utilization rate were to change in the case of another sailing route.

For simplicity there will also be a *ceteris paribus* assumption meaning that the only variable cost that can change in this computation is the bunker fuel cost, all other variables will be held constant. This also includes exogenous variables like foreign exchange rates, random shocks, shipbuilding production world fleet and other supply and demand influencing variables.

The added price premium on distillate fuel used in the computation will be 80%, this is partly based on historical data showed in figure 29, where it was calculated that the premium the last 7 months was 71%. In addition to this calculation I have based the estimated premium on statements made by market participants. Examples of this is the Interferry estimate of an 80 – 100 % increase in bunker costs stated in a sustanebleshipping.com (10.2008) article, as

well as TT-line's rapport (12.2008) concerning low sulphur fuel where their estimates were an 80 % increase in bunker costs resulting from a change in bunker fuels. As mentioned in chapter 4.1.2, it is not unlikely that this premium will be even higher due to supply shortages and an additional refinery investment. I therefore consider an 80% increase in the price premium a realistic estimate in a case where scrubbers are not a part of the sulphur reducing solution, which is an assumption in this calculation.

There will also be made an assumption concerning the tax on CIF cost. The reason for this is the fact that tariffs and added taxes are generally calculated using the commodities CIF price which, as mentioned in chapter 3.3.1, includes transport and insurance, meaning that an increase in transport cost will affect taxes. This tax is set to 20% which is an estimated average in Europe (export.gov, 2009). In addition to this I have used a required return of 10% which also will be affected by an increase in the operational costs.

The bunker price used in Stopford 2009 calculations is 300\$/mt, which is fairly close to the price seen the last six months; however it is quite likely that the crude oil price will rise significantly by 2015. Therefore, I have decided to use two scenarios to calculate the freight rate increase. The first scenario will be calculated using Stopford 2009, (and the current) price on bunker fuel (300\$).

The reason for these calculations is to give an estimate of the change in general container transport freight rates due to a cost increase in bunker fuel as a result of Annex VI. As mentioned, the numbers used as a base for the calculation are not very relevant in this calculation, however I will assume that the cost proportions used in this example will match a smaller ship in a shorter route fairly well.

Table 4: Calculations of freight rate effects with IFO 380 Price at 300\$ (\$000 per voyage)

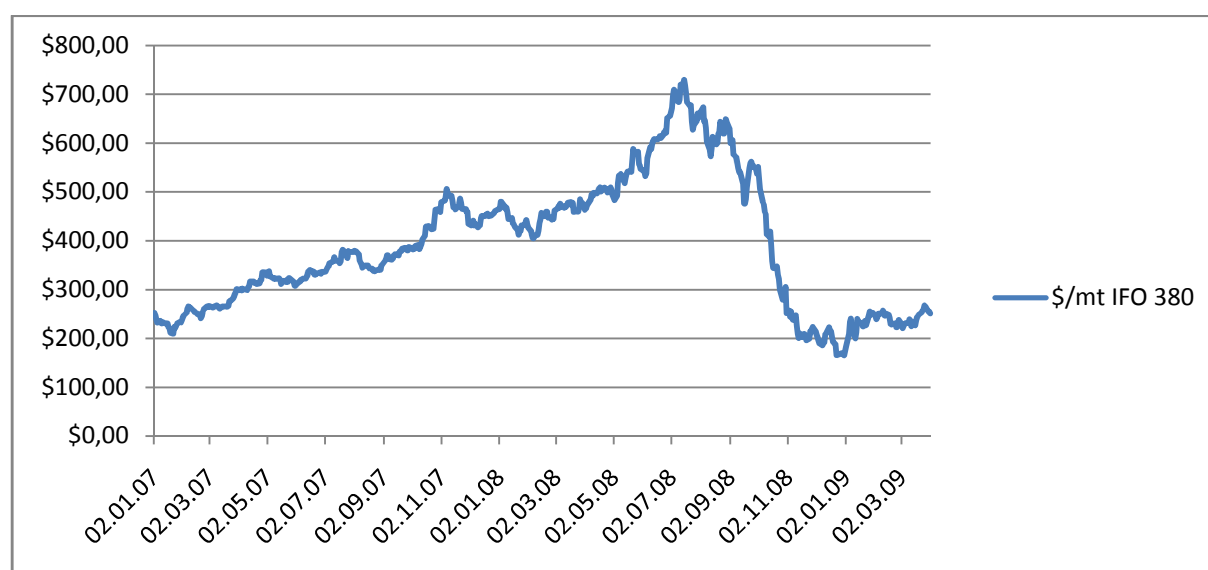
	Before switch to MGO	With MGO at 540\$
Operating costs	179	179
Capital costs	343	346
Port costs	154	154
Bunker costs	426	767
bunker cost, % of total costs	21 %	32 %
Total ship costs	1102	1446
Voyage costs, % of total costs	54 %	61 %
Costs of the containers on a voyage	66	66
Container costs, % of total costs	3 %	3 %
Administration costs per voyage	146	146
Administration costs, % of total costs	7 %	6 %
Cargo handling and onward transport	713	713
Cargo handling and onward transport, % of total costs	35 %	30 %
Total voyage costs	2027	2371
10 % Required return (profit)	203	237
20 % added tax on freight	446	522
Freight rate	2676	3130
Freight rate change from before MGO		17 %

Source: Stopford 2009 and own calculations.

As shown in the table above, the bunker share of the total cost rises with 11%, which affects the operational costs per voyage adversely. This adverse cost effect leads to a freight rate increase of 17%. As mentioned above this estimate is a fairly conservative one and will probably be a “best case scenario”.

The second scenario will be based on one of the highest reported IFO 380 prices in Rotterdam port the last three years which is shown in the graph below.

Table 5: 3 Year Rotterdam IFO 380 prices



Source: Bunkerworld.com

The reason for this price estimate is that the author feels it will be somewhat misleading to use today's prices considering the world economic situation. I will therefore initially use an IFO380 price of 700\$/mt when calculating the second scenario. This price example is taken from the general crude oil price outlook when it peaked in August 08 costing 145\$ per barrel. At this time Gazprom, the Russian energy giant estimated that oil prices could reach 250\$ per barrel (Blas, J. 2008). This estimate was considered to be rather excessive; however with an upturn in the economy it will not be unlikely to see prices above 200\$ per barrel within 2015. If this is the case it will not be unlikely that IFO 380 prices can be expected close to 1000\$ per ton, based on own calculations that indicated an average 2008 price differential on IFO 380 at 4,8 times the price of crude oil. This implies that at a crude oil price of 200\$ per barrel, the IFO 380 can be expected to be 960\$/mt Cet par. The calculations based on IFO 380 prices when crude oil prices peaked in 2008 are shown in the table below.

Table 6: Calculations of freight rate effects with IFO 380 price at 700\$ (\$000 per voyage)

	Before switch to MGO	With MGO at 1260\$
Operating costs	179	179
Capital costs	343	346
Port costs	154	154
Bunker costs	979	1762
bunker cost, % of total costs	37 %	52 %
Total ship costs	1655	2441
Voyage costs, % of total costs	63 %	73 %
Costs of the containers on a voyage	66	66
Container costs, % of total costs	3 %	2 %
Administration costs per voyage	146	146
Administration costs, % of total costs	6 %	4 %
Cargo handling and onward transport	713	713
Cargo handling and onward transport, % of total costs	27 %	21 %
Total voyage costs	2634	3366
10 % Required return (profit)	263	337
20 % added tax on freight	579	740
Freight rate	3476	4443
Freight rate increase from before MGO		28 %
Freight rate increase from today (at \$300)		66 %

Source: Stopford 2009 and own calculations

As the table shows the bunker cost proportion will increase to 37% of the total costs at an IFO 380 bunker price of 700\$, which will increase to 52% after switching to MGO. When the oil price are at these high levels, the shipping industry is even more vulnerable to cost increases on bunker, which in this high oil price example led to a freight rate increase of 28% as a consequence of Annex VI, and a 66% increase compared to today's levels at approximately 300\$/mt.

The estimated freight rate increase of 28% as a result of a switch to distillate fuels after January 2015, is as mentioned a general estimate only to illustrate how the bunker fuel can affect transport rates as a result of the ECA 0,1 % sulphur cap. However, the 28% freight rate increase estimate is close to the range of what the industry believes will be the case. This is supported by several articles and rapports concerning this issue. Examples of this is an EU rapport (Meech, R. 2005) concluding that the freight rate increase in the Mediterranean Sea can increase with as much as 45% if it (the Mediterranean Sea) is incorporated in the ECA area, as well as statements made by Interferry to suatanebleshipping.com (10.2008) claiming that freight rates could increase by as much as 30 – 50% to cover the extra fuel costs.

On the basis of the calculations made in table 6, as well as the industries predictions which range from 20 - 60% freight rate increase on liner shipping within ECA areas, I will use a 28% freight rate increase as a point of reference in my further analysis, regarding the implications this will have on the transport market.

4.3 Effects on liner shipping

An increase in the operational costs will affect a shipping company adversely, depending on several factors. The most prominent ones being:

- Cost structure of the company
- Shipping margin
- Market structure/power-substitutes
- Elasticity of market demand on the goods transported
- Value-to-weight ratio on the product transported

4.3.1 Effects on transport demand

As explained in chapter 2.1 concerning trade; “the reason why trade takes place is because somebody makes a profit from it. The profit is achievable because of cost differences between countries, and if the cost savings are large enough to cover transport costs and tariffs, someone will capture this arbitrage opportunity and trade will take place”. This

implies that when the transport costs increase, it will result in diminishing returns for the companies that have established their business in foreign countries in order to gain from a countries comparative advantage as explained in chapter 2.1.1 and 2.2.2.

A recent example of a company that built a production plant closer to a large market because of the soaring oil price and consequently increasing transport costs seen in 2008, was the Swedish furniture manufacturer IKEA, which will open its first factory in the United States in May 2009 (Hennigan, M. 2008). In addition to this, several electronic manufacturers that left Mexico due to the lower wage level in China moved their production back to Mexico in 2008, because of the lower transport cost of trucking their output to American consumers (Hennigan, M. 2008).

According to a rapport made by CIBC (Rubin, J. 2008) the transport costs constituted the same as a 3% US tariff rate in 2000 when the oil price was at 20\$ per barrel. However at 150\$ per barrel the US transport cost would be equivalent to a tariff of 11% which would reduce the US wage arbitrage with China. I am aware that the examples used are not directly related to European short sea shipping; however it is relevant when explaining the relationship between transport costs and its effects on comparative advantage. In northern European trade the comparative and absolute advantages are most prominent in the trade between Eastern Europe and Western Europe due to larger differences in wage levels and technological development as explained in chapter 2.1. This means that it is probably the commodities shipped from east to west that will be the most price sensitive commodities in a case of a freight rate increase.

The transported product's characteristics are relevant when analyzing the effect of a freight rate increase, in general the goods that have a high value-to-weight ratio will not be affected as much as products with low value-to-weight ratio as explained in chapter 3.3.1. To analyze to what extent a product is affected by a freight rate change, the transport demand elasticity has to be known, this is a function of the final demand elasticity for the product in the country of destination. This thesis will not regard any product in particular, because of the difficulties of finding accurate estimates regarding this subject. However, a universal

example will be given to illustrate in general what the effects can be in the case of a freight rate change.

To illustrate how a freight rate increase could affect trade patterns, and consequently the demand for transport, I will construct an example using numbers. Some assumptions have to be made; I will use examples with a both high and low oil prices (300\$ and 700\$) as in the previous examples. The reason for this is to separate the effects of oil price changes and Annex VI on the final cost increases. A quay to quay transport cost of 8% will be used assuming bunker costs of 300\$/mt per. Because the numbers used to calculate the freight rate increase are based on container transport, the results from the calculations below will also be based on general short sea container shipping. The calculations do not consider substitute transport modes as available. It is further assumed that the commodity group in question has an elasticity of demand of 1,3 which is relatively high and the commodity can be assumed to be luxury goods like furniture or white goods which will have fairly high transport costs (Rubin, J. 2008) due to their physical characteristics (high volume/value).

Table 7: Change in transport costs

Pre Annex VI trans cost at 300\$	8 %
Trans cost with 17% freight rate increase	9,36 %
Price increase	1,36 %
Decrease in demand (elasticity= 1,3)	1,80 %
Pre Annex VI trans cost at \$700	10,40 %
Trans cost with 28% freight rate increase	13,30 %
Price difference total (compared to 8% T. cost)	5,30 %
Price increase due to Annex VI	2,90 %
Decrease in demand; total (elasticity 1,3)	6,90 %
Decrease in demand due to Annex VI	3,77 %

Source: Own calculations

As the table above shows there will only be a total commodity price increase of 1,36% and a decrease in demand of 1,8% as a result of Annex VI in the case of low oil price. As mentioned in chapter 1.3, world trade has grown on an average with 4.8% after World War II, with a

demand decrease in trade by 1,8%. As a result of a switch to distillates, it will be quite safe to conclude that a trade decrease will not affect short sea shipping to a great extent at these bunker price levels.

In the high oil price example, the total cost effects were significantly larger with a 5,3% increase in the price difference compared to the low cost example. This cost increase would result in a 6,3% decrease in demand; however the effect caused by a switch to distillates was only a 2,9% price increase and a 3,77% demand decrease, which will probably not have particularly adverse effects on the demand for short sea liner services especially if the 4.8% growth in trade is taken into account, as well as the cost volatility related to international trade, like exchange rate fluctuations and supply/demand distortions leading to volatile freight rates. It has to be pointed out that these calculations are based on round handed estimations that are founded on real world conditions.

Even if the effects relating to medium/high value commodities will probably not be substantial, some issues concerning the low value “bottom cargoes” can exist. These are often used to fill up the ship using marginal cost pricing and price discrimination strategies. This is explained in chapter 2.6 and 3.5.1 and is only an appropriate strategy on routes with uneven trade balance, in order to help cover some of the average costs. After a switch to distillate fuels the marginal costs will increase, thus resulting in a rise of the supply curve. The marginal cost pricing strategy for these goods will firstly aim to cover the costs relating to cargo handling. At every freight price above this level the marginal cost goods will start covering the bunker fuel cost and other voyage costs. This means that a bunker cost increase does not directly affect the bottom cargoes. However, the indirect effect of staying longer at port results in increased voyage costs because of the increased speed the vessel will have to steam as a result of a tighter schedule. As these “bottom cargoes” are relatively price sensitive, it will probably result in a decrease of transport demand for these cargoes as it, in some cases, will probably not be profitable to transport “bottom cargoes” with the lowest value-to-weight ratio on container ships anymore.

It can be stated that the effects of switching to distillate fuels on a route with no possible substitutes will not have substantial effects on trade alone, because of the small proportion of the commodities CIF value that actually consists of the freight cost element. In addition to this, a large amount of the goods that is transported with north European short sea shipping services has already induced a freight cost being transported by a deep sea service, as they come from parts of the world with higher comparative advantage than the countries in Europe has in excess of each other. This means that these goods which are shipped by a short sea feeder service from the main international “gateway” ports will be affected to a lesser extent than goods produced in Europe and exported within northern Europe as a result of the increased transport cost share caused by Annex VI. However, there will probably be some effects in the case of high oil price, which indicates that in the isolated example used above, the largest adverse effect on trade and consequently the demand for sea transport is dependent on the future oil price. The oil price outlook will also be one of the largest determinants to how large adverse effects Annex VI will have on northern European short sea shipping freight rates.

4.3.2 Modal shift

A major concern relating to the bunker cost increase in the industry, is the fact that a modal shift towards road haulage is a quite likely consequence. This concern is especially evident on the routes where there exist substitute transport modes or where there can be established new competing land based routes that may become competitive because of the increased costs faced by short sea shipping.

It seems that the fear of modal shift towards road haulage is the largest concern the liner shipping industry has in relation to the new MARPOL regulations. Examples of this are Stena Line’s estimates of a 20 – 40% loss of trucks being shipped in short sea shipping (Stena Line 2009), and the ESCA (European community shipowners association) secretary general Alfons Guinier’s statements to Lloyds list saying that: “There is a potential danger that the additional costs for short sea shipping will result in a shift from the sea to the less environmentally credible land based transport” (Stares, J. 2008).

For a modal shift from short sea shipping to road haulage to be a concern, the two substitutes will have to have relatively equal marginal costs if they offer the same quality of service before January 2015. However, they can be competitors even with significant marginal cost differences, in this case the transport mode with the highest transport cost has to justify this with superior transport quality which is explained in chapter 3.4.

In a case where the two transport modes have similar marginal costs and no significant quality differences, a cost increase of 17% in a low oil price scenario, or a 28% increase in the case of high oil price, will probably have an adverse effect on the competitiveness of containerized sea transport. However, according to a rapport made by SSB (statistics Norway) (Lund, V. 2001) the average diesel cost share of the total costs for a Norwegian truck owner amounted to 19 – 24% in 1997, depending on the type of truck. It has to be noted that these are fairly old numbers, nevertheless it shows that fuel costs constitute a significant part of the trucks total costs. This means that in the case of a crude oil price of 150\$, there will also be additional fuel costs associated with road haulage compared to today's price level. In addition to this, it is likely that the price of diesel fuel used in trucks will rise as a result of the increased demand for distillate fuels from the shipping industry after January 2015. Even with these cost increases, also faced by road transport, it is quite evident that the short sea shipping industry can face competitive difficulties due to a substantial (minimum 17%) increase in total operating costs as an "isolated" result of the switch to distillate fuels.

The liner companies that struggle with low profitability due to competing land based transport modes before January 2015, will most likely experience a modal shift towards road haulage especially in the short run because they will be unable to cover the increased average costs due to the short run rigidity in the cost structure as explained in chapter 3.5 and 2.4.1.

In the longer run the supply of transport tend to get more elastic due to more flexible cost structure and technological developments concerning emission reductions, this long run supply characteristic is explained in chapter 2.4.1. This means that in the longer run the most vulnerable short sea shipping routes can regain its lost competitiveness on road transport

because of technological developments and restructuring. As mentioned in chapter 1.2 the technological developments in liner shipping is one of the most prominent reasons for the increased globalization seen the last 50 years, there are no reason to believe that this efficiency improvement would discontinue in the future. The technological developments in the shipping industry will probably cancel out the adverse effects caused by a cost increase on bunker fuel within a reasonable time period.

The goods that will be most affected in case of a significant short run freight rate increase are the low value-to-weight goods, especially the “bottom cargoes” mentioned in chapter 1.4. These goods are usually not very time sensitive (Hummels 2001), and the shippers of these cargoes can wait for a backhaul with a truck, or choose road transport or bulk shipping if this is the cheapest option regardless of the quality of service. This will probably not affect short sea shipping dramatically because these goods only cover a proportion of the costs and usually do not generate any revenue (Stopford 2009).

It seems that it is the Ro/Ro industry which has the highest concerns (Stena Line 2009 and TT-Line 2008) relating to modal shifts, this is possibly because this shipping segment has higher bunker cost shares compared to the Lo/Lo segments, which has a larger cost proportion linked to cargo handling, consequently making the relative bunker costs lower than in Ro/Ro segments.

As explained in chapter 3.4, regarding transport demand there are several factors in addition to transport costs that can influence transport demand. In addition to this, the liner company can take some measures regarding their supply of transport, which can reduce costs, in order to stay in business, especially in the longer run. These measures are explained in chapter 3.3 and involve reducing the speed of the vessel, restructuring the business in order to achieve better scale economies compared to road transport as well as implementing other fuel effective measures. However, it is important to compare these measures to the revenue effects and quality of service.

4.4 Conclusion

The purpose of this thesis is to uncover the possible effects that the revised MARPOL Annex VI can have on the short sea liner industry with main emphasis on container transport. This research was conducted using trade theory, microeconomic theory as well as transport economic theory as a basis for the analysis. Various forms of data were obtained from several industry participants as well as governmental organizations and relevant curriculum literature.

During the work of this thesis it became apparent that the additional costs faced by both shippers as well as ship-owners were substantial, according to Stena Line (2009) the additional costs facing European industry within ECA areas using average 2008 oil prices will amount to 10 billion dollars, which is a substantial amount. In addition to the industries estimates, the author has estimated a freight rate increase of 17% and 28% depending on the world oil price. It was pointed out that there are some uncertainties related to these estimations. Nevertheless, it was concluded that the major concern towards increasing freight rates was increasing oil prices and that in the case of high oil prices the effects of a switch to distillate fuels would only increase this adverse effect and not be the key contributor to the increase in the freight rates.

The increased freight rate proportion caused by Annex VI will probably not have significant effects on trade patterns; however, it is possible that some low value commodities can be affected to some degree, especially with a considerable increase in oil prices compared to today's level. Taking an isolated look at the 10 billion dollar estimate, it appears as a very large number; though according to wto.org (2008) the total value of EU's merchandise trade in 2007 was 5314 billion dollars, which means that the estimated 10 billion \$ additional costs only amounts to 0,19% of the total EU trade value. Looking at the numbers in this perspective, the cost increase impacts seem less significant.

The concerns regarding modal shifts appear to be warranted for the operators with the lowest margins and who are already in fierce competition with road transport. However, it seems that it is the Ro/Ro industry that will have the largest problems due to their cost

structure, and the obvious advantage road haulage has as regards to the speed of transport on some routes.

There is little doubt that measures taken to reduce sulphur emissions from the shipping industry will add costs and challenges related to the supply of distillate fuels, as well as the development of reliable and cost effective sulphur abatement technologies. The costs will affect ship-owners as well as the shipper, and consequently the consumer of the end product. Nevertheless, it seems to the author that the additional costs added to transport, because of this environmental measure, is not substantial enough to cause any serious supply and demand distortions or significant changes in trade patterns.

5 Discussion

In above chapters the author has attempted to highlight the main issues regarding the transport industry derived from the revised MARPOL Annex VI with subsequent market reactions. Even though several supplementary issues could have been included, the author is confident that the findings supplied in this thesis give clear signs as to how large and to what extent the market impact of the revised Annex VI will be.

Furthermore, the author has not attempted to thoroughly discuss the environmental effectiveness and the benefits to society as a result of the new regulations, or the effects faced by the world shipping fleet in 2020 or 2025 when the world sulphur cap will be reduced to 0,5%. These matters make for interesting material for further research.

5.1 Objectives were met

The aims and objectives were stipulated in the introductory part of this thesis. The main objective was to uncover the market impacts due to the revised MARPOL Annex VI. The author set out to discover whether or not the stricter sulphur emission regulations would impact the market in a commercial way through increasing freight rates, as well as impacting trade patterns. Through the previous chapters, various forms of data have been shown and explained, creating an understanding of how the freight rates are derived by a variety of supply and demand factors.

5.1.1 Difficulties met with research & data collection

Even though the author is content with the findings derived from the information available, there will always be difficulties encountered when working on a research project of this size. This project was no different, and there were several difficulties encountered when working on this thesis. The major problem is related to the gathering of information and data. The reason for this is the problems relating to knowing where to access the correct and relevant data, and most important to know how to get it. The shipping industry is a secretive business, which resulted in considerable difficulties faced by the author in order to gain

access to relevant data. The author contacted a number of shipping companies as well as a brokerage firm specialized in bunker brokerage and trading. This consequently resulted in some relevant information concerning fuel prices and availability of distillate fuel from the brokerage firm, whereas the shipping firms were not especially cooperative, which resulted in the use of cost estimates derived from Stopford 2009. Nevertheless, the author feels confident that the data material used to obtain the conclusions in this thesis, including own calculations and economical theory, supported by secondary data, are credible.

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